# FEASIBILITY STUDY WORK PLAN

## Lower Passaic River Study Area
## Remedial Investigation/Feasibility Study
## Revision 2

*Prepared for*
**Lower Passaic River Cooperating Parties Group**
New Jersey

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# CONTENTS





FOIA_07123_0003165_0002

FOIA_07123_0003165_0003

# LIST OF FIGURES



# LIST OF TABLES





FOIA_07123_0003165_0004

# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| 2,3,7,8-TCDD | 2,3,7,8-tetrachlorodibenzo-*p*-dioxin |
| 2007 Settlement Agreement | Administrative Settlement Agreement and Order on Consent |
| AOC | Administrative Order on Consent |
| ARAR | applicable or relevant and appropriate requirement |
| BERA | baseline ecological risk assessment |
| CAD | confined aquatic disposal |
| CAG | community advisory group |
| CDF | confined disposal facility |
| CERCLA | Comprehensive Environmental Response, Compensation and Liability Act |
| CFR | Code of Federal Regulations |
| cfs | cubic feet per second |
| COC | contaminant of concern |
| COPC | contaminant of potential concern |
| CPG | Lower Passaic River Cooperating Parties Group |
| CSM | conceptual site model |
| CSO | combined sewer overflow |
| cy | cubic yard |
| Early Action FFS | draft source control early action focused feasibility study |
| EPA | U.S. Environmental Protection Agency |
| EPA Sediment Guidance | Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA 2005) |
| FFS | focused feasibility study |
| FS | feasibility study |
| FSP | field sampling plan |
| FSWP | feasibility study work plan |
| GRA | general response action |
| HHRA | human health risk assessment |



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|---|---|
| LPR | Lower Passaic River |
| LPRRP | Lower Passaic River Restoration Project |
| LPRSA | Lower Passaic River Study Area |
| LRC | low-resolution coring |
| MLW | mean low water |
| MNR | monitored natural recovery |
| NCP | National Oil and Hazardous Substances Pollution Contingency Plan |
| NGVD | National Geodetic Vertical Datum |
| NJDEP | New Jersey Department of Environmental Protection |
| NJDOT | New Jersey Department of Transportation |
| NOAA | National Oceanic and Atmospheric Administration |
| NPL | National Priorities List |
| NRDA | natural resource damage assessment |
| NRRB | National Remedy Review Board |
| O&M | operations and maintenance |
| OCC | Occidental Chemical Corporation |
| OU | operable unit |
| PAH | polycyclic aromatic hydrocarbon |
| PCB | polychlorinated biphenyl |
| PCDD | polychlorinated dibenzo-*p*-dioxin |
| PCDF | polychlorinated dibenzofuran |
| PQL | practical quantitation limit |
| PRG | preliminary remediation goal |
| PRP | potentially responsible party |
| RAL | remedial action level |
| RAO | remedial action objective |
| RARC | risk analysis and risk characterization |
| RBTC | risk-based threshold concentration |
| RG | remediation goal |



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|---|---|
| RI/FS | remedial investigation and feasibility study |
| RM | river mile |
| ROD | record of decision |
| SOW | statement of work |
| SSP | supplemental sampling program |
| SWAC | surface area-weighted average concentration |
| SWO | stormwater outfall |
| TBC | to be considered |
| TCRA | time-critical removal action |
| Tierra | Tierra Solutions, Inc. |
| TMDL | total maximum daily load |
| TMO | Tierra Solutions/Maxus/Occidental Chemical Corporation |
| USACE | U.S. Army Corps of Engineers |
| USFWS | U.S. Fish and Wildlife Service |
| VOC | volatile organic compound |



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# 1 INTRODUCTION

This feasibility study work plan (FSWP) has been prepared as part of the Lower Passaic River Study Area (LPRSA) remedial investigation and feasibility study (RI/FS), which is being performed by the Lower Passaic River Cooperating Parties Group (CPG), in accordance with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and under the oversight of the U.S. Environmental Protection Agency (EPA).

The FSWP presents the scope and detailed procedures to conduct the feasibility study (FS) for the LPRSA, which encompasses the 17.4-mile tidally influenced portion of the Lower Passaic River (LPR) and its tributaries from Newark Bay upstream to Dundee Dam (Figure 1-1).. The LPR is an integral part of the Greater Newark Bay complex, along with Newark Bay, Hackensack River, Arthur Kill, and Kill Van Kull.

The LPRSA is an operable unit of the Diamond Alkali Superfund Site. In May 2007, EPA entered into an Administrative Settlement Agreement and Order on Consent (2007 Settlement Agreement; USEPA 2007) with the CPG to complete the RI/FS for the LPRSA.[1] The RI/FS provides a comprehensive study of environmental conditions, human health and ecological risks, and remedial alternatives for the entire 17.4 miles of the LPRSA.

The initial draft FSWP was first submitted to EPA in August 2008. The CPG submitted a revised draft FSWP to EPA in March 2009 (AECOM 2009), in response to agency comments received in November 2008. EPA provided comments to the CPG on the 2009 revised draft FSWP on December 13, 2013. This revision to the draft FSWP addresses EPA's December 2013 comments and reflects a subsequent discussion held with EPA in a meeting on December 17, 2013, regarding the FS status, approach, and schedule.

The FS process described in this FSWP will present and evaluate a range of cleanup approaches to address the entire 17.4 miles of the LPRSA. EPA has performed other remedial evaluations in the LPRSA, which are presented in the draft source control early action focused feasibility study (Early Action FFS), initially issued by EPA in 2007 (MPI 2007b) and expected to be finalized in early 2014. EPA's Early Action FFS, described further below, addresses only the lower 8.3 miles of the LPRSA and emphasizes bank-to-bank approaches to sediment cleanup.

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[1] The CPG includes more than 60 cooperating members identified as potentially responsible parties (PRPs) for environmental response action in the LPRSA. Many other parties who have been identified as potentially responsible are not members of the CPG. Most notably, Tierra Solutions/Maxus/Occidental Chemical Corporation (TMO), considered the most significant responsible party due to significant contribution of 2,3,7,8-TCDD, is no longer part of the CPG as of June 2012 and no longer funding the RI/FS effort. In 2012, EPA issued a Unilateral Administrative Order against Occidental for its failure to contribute toward the CPG's removal of 2,3,7,8-TCDD-contaminated sediment at RM 10.9. TMO is also obligated and has not yet initiated Phase 2 of its removal action, which includes the removal and disposal of an additional 160,000 cubic yards of dioxin-contaminated sediments in the vicinity of RM 3, adjacent to the Lister Avenue site.



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## 1.1 REGULATORY SETTING

The RI/FS work required by the Settlement Agreement is being conducted under CERCLA, as implemented through the regulatory requirements of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR § 300.430). The FS process, and any potential response action selected based on the FS, must comply with CERCLA and be performed in a manner consistent with its associated guidance. The specific documents defining the conduct of the FS process on the LPR include:

- 2007 Settlement Agreement (USEPA 2007)
- Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA 1988)
- Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites (USEPA 2002a)
- Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA 2005)
- A Guide for Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents (USEPA 1999)
- A Guide for Developing and Documenting Cost Estimates during the Feasibility Study (USEPA 2000)
- A Risk Management Strategy for PCB-Contaminated Sediments (NRC 2001).

### 1.1.1 The Diamond Alkali Superfund Site

The Diamond Alkali Superfund Site consists of three operable units, of which the LPRSA is Operable Unit 2 (OU2). The other two operable units are the former Diamond Alkali pesticide manufacturing plant and surrounding properties at 80 and 120 Lister Avenue in Newark, New Jersey (OU1), and the Newark Bay Study Area (OU3). The upland properties within OU1 are on the south bank of the LPR at river mile (RM) 3.2 (Figure 1-2). OU1 was left uncontrolled from approximately the late 1960s to mid-1980s, at which time the State and EPA became involved because elevated levels of dioxin contamination were found at the site. An interim remedy for OU1 was implemented to prevent direct exposures to the contaminated soils and contaminated buildings and debris, prevent further migration of the contaminated groundwater, and prevent surface runoff of stormwater. The remedial actions for OU1 included capping of contaminated soils and debris on site, constructing a slurry wall and flood wall, and pumping and treating of the contaminated groundwater. All construction activities were completed on June 2, 2004. The delay by respondents responsible for the major dioxin source in the river allowed dioxin to migrate throughout the LPRSA. The Newark Bay Study Area is a portion of the New York/New Jersey Harbor estuary and consists of Newark Bay and portions of the Hackensack River, the Arthur Kill, and the Kill Van Kull. RI activities are ongoing in OU3. Remedial activities in OU1 and OU3 are not governed by the 2007 Settlement Agreement between EPA and the CPG and are being carried out separately from the LPRSA RI/FS.

In addition to the 2007 Settlement Agreement providing for the completion of the LPRSA RI/FS, the following agreements have been reached to perform sediment removal actions under CERCLA in portions of the LPRSA:

- Under a Settlement Agreement executed on June 23, 2008, by and between EPA, Occidental Chemical Corporation (OCC) and Tierra Solutions, Inc. (Tierra), OCC agreed to fund and perform the removal and disposal of 200,000 cubic yards (cy) of LPR sediment located adjacent to OU1 of the Diamond Alkali Superfund Site. The primary objective of the work was to remove a significant portion of the most concentrated inventory of dioxin-contaminated sediments, thereby removing source material that poses a potential risk to human health and the environment, and to minimize the possibility of migration of contaminants due to extreme weather events (USEPA 2008a, 2009). Sampling conducted in the Phase 1 removal area (2011 Lister Avenue Joint Defense Group Sediment Sampling) detected the highest concentrations of dioxin in the river. These data indicate that the deposits adjacent to OU1 contain the highest mass of dioxin contamination in the river. These data, evaluated in conjunction with the CPG data sets, demonstrate that the mass of dioxin within the LPRSA decreases away from the OU1 source area (CPG 2013). On January 9, 2009, EPA, in consultation with the New Jersey Department of Environmental Protection (NJDEP), issued an Action Memorandum and selected the final plan for the Phase 1 non-time-critical removal action. In 2011, OCC entered into an Administrative Order on Consent (AOC) with EPA requiring the removal, under Phase 1, of 40,000 cy of the most elevated dioxin-contaminated sediments from the LPR in a 2-acre area in the immediate vicinity of the Lister Avenue site (Figure 1-2), and an additional future removal of 160,000 cy of LPR sediments from an adjacent shoreline area on either side of the Phase 1 removal action (Phase 2). The Phase 1 removal was initiated in July 2011 and completed in December 2012. The Phase 2 removal has not been completed and is currently unscheduled.
- Under a Settlement Agreement executed on June 18, 2012, by and between EPA and the CPG, the CPG agreed to fund and perform the removal and disposal of between 15,000 and 20,000 cy (top 2 ft) of LPR sediment within a mudflat at RM 10.9 (Figure 1-3). The objective of this work was to remove surficial sediments with elevated concentrations of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD), polychlorinated biphenyls (PCBs), and other contaminants of potential concern (COPCs) and cap in place remaining sediments to reduce the potential for exposure to receptors and to prevent potential migration of contamination from the RM 10.9 removal area. The RM 10.9 removal action, which is being conducted under CERCLA authority as a time-critical removal



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action (TCRA), was initiated in July 2013. The removal of a final volume of 16,050 cy of sediments was completed on October 3, 2013, followed by capping, scheduled for completion in February 2014.

### 1.1.2 Lower Passaic River Restoration Project

The Lower Passaic River Restoration Project (LPRRP), congressionally authorized in 1999 under CERCLA and the Water Resources Development Act, is a remediation and ecosystem restoration initiative for the LPR watershed. The RI/FS for the LPRSA was identified in the 2007 Settlement Agreement as a component of the LPRRP. In addition to EPA, several other federal and state agencies—collectively designated under the Settlement Agreement as "Partner Agencies"—have been designated as LPRRP participants. These include the U.S. Army Corps of Engineers (USACE), the New Jersey Department of Transportation (NJDOT), the National Oceanic and Atmospheric Administration (NOAA), the U.S. Fish and Wildlife Service (USFWS), and NJDEP.

In addition to the RI/FS, other studies of the LPR are occurring as part of the LPRRP. USACE is conducting studies that consider opportunities for ecological restoration, flood control, and navigational improvements. EPA is conducting total maximum daily load (TMDL) studies for improving water quality in the Passaic River and other water bodies in the New York/New Jersey Harbor complex. State and federal trustees for natural resources (NOAA, USFWS, and NJDEP) are also conducting a natural resource damage assessment (NRDA) under the LPRRP.[2]

### 1.1.3 EPA Focused Feasibility Study

In June 2007, shortly after entering into the 2007 Settlement Agreement with the CPG in May 2007, EPA issued a draft Early Action FFS to address sediments in the lower 8.3 miles of the river, which EPA identified as a major source of contamination to the 17-mile study area and to Newark Bay (MPI 2007b).

> "…[T]his Focused Feasibility Study (FFS) was undertaken to evaluate a range of remedial alternatives that might be implemented as an early action to control that major source. The Source Control Early Action, if undertaken, would address contaminated sediments in the lower eight miles of the Passaic River, in order to more rapidly reduce risks to human health and the environment. The Source Control Early Action, which would be a final action for the sediments in

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[2] In December 2008, NOAA and USFWS entered into an interim funding agreement with a subset of member companies of the CPG. The purpose of this agreement is to identify possible early restoration measures and work cooperatively to conduct damage assessments. The agreement also provides a mechanism to reimburse the federal trustees for a portion of their past costs, as well as providing funding for a portion of future costs associated with pursuing a cooperative NRDA of the LPRSA.



FOIA_07123_0003165_0011

> the lower eight miles, is intended to take place in the near term, while the comprehensive 17-mile Study is ongoing."

After its release in 2007, the Early Action FFS was presented in numerous public forums and reviewed by EPA's Contaminated Sediments Advisory Group in February 2008; CSM Peer Review in May and June 2009; the National Remedy Review Board (NRRB) in December 2012; and the FFS Model Peer Review in September 2013. A revised draft Early Action FFS was submitted to the NRRB in 2012; the revised draft Early Action FFS and the results of the NRRB's review have not been released to the public.

Although EPA has not yet released a final FFS, it has provided recent updates on its progress to the Passaic River Community Advisory Group (CAG), including a written summary of the FFS provided to the CAG on October 12, 2012 (USEPA 2012a) and presentations to the CAG on November 7, 2013, and January 9, 2014. Based on information presented in these updates, EPA is evaluating four remedial alternatives in the FFS:

**FFS Alternative 1—No Action**

**FFS Alternative 2—Deep Dredging with Backfill:** dredging of all fine-grained materials in the lower 8.3 miles, including restoration of the federal navigation channel from RM 0 to 8.3.

**FFS Alternative 3—Capping with Dredging for Flooding and Navigation:** dredging for placement of an engineered cap in the lower 8.3 miles, including restoration of the federal navigation channel in the lower 2.2 miles.

**FFS Alternative 4—Focused Capping with Dredging for Flooding:** dredging of 223 acres of fine-grained sediments to a depth of 2.5 ft, with placement of an engineered cap in the lower 8.3 miles. FFS Alternative 4 has no provisions for restoration of the navigation channel.

## 1.2 The Feasibility Study Process

The purpose of an FS is to develop and evaluate a range of alternative methods for achieving the proposed remedial action objectives (RAOs) for the LPRSA CERCLA site. The FS process lays the groundwork for proposing and selecting a remedy that addresses site-related risks to human health and the environment, taking into account nine evaluation factors specified under the NCP (40 CFR § 300.430(e)(9)(iii)), including overall protection of human health and the environment; compliance with applicable or relevant and appropriate requirements (ARARs); long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; cost; state acceptance; and community acceptance.

The FS process follows several steps outlined in the RI/FS CERCLA guidance (USEPA 1988), as well as elements outlined in Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (hereinafter referred to as "EPA Sediment Guidance") (USEPA 2005).

### 1.2.1 Definitions for the Feasibility Study

Key terms that will be used in the FS are defined in this section, along with the appropriate regulatory citations, where applicable.

**Applicable or relevant and appropriate requirements (ARARs)** are promulgated federal and state standards, requirements, criteria or limitations that are determined to be "applicable" or "relevant and appropriate" to a CERCLA response action. Under Section 121(d) of CERCLA, an "applicable" requirement is a promulgated federal or state standard that specifically addresses a hazardous constituent, remedial action, location or other circumstance at the site. For a requirement to be applicable, its intended scope and authority must encompass the planned remedial actions and/or circumstances at the site. A "relevant and appropriate" requirement is a promulgated federal or state requirement that addresses problems or situations similar to those encountered at a site, even though the requirement is not legally applicable.

**Background** is defined by USEPA (2002b) as "[s]ubstances or locations that are not influenced by the release from a site and are usually described as naturally occurring or anthropogenic: (1) Naturally occurring substances are present in the environment in forms that have not been influenced by human activity, (2) Anthropogenic substances are natural and human-made substances present in the environment as a result of human activities (not specifically related to the CERCLA site in question)." Furthermore, USEPA (2002b) describes background and reference areas as "[t]he area where background samples are collected for comparison with samples collected on site. The reference area should have the same physical, chemical, geological, and biological characteristics as the site being investigated, but has not been affected by the activities on the site." Similar definitions are identified in NJDEP's ecological risk assessment guidance.[3] All of the definitions provided by USEPA (2012b) identify background as concentrations of contaminants in environmental media. Therefore, for the purposes of the baseline ecological risk assessment (BERA), baseline human health risk assessment (HHRA), and FS, background will refer to concentrations of contaminants found in the surface water, sediment, and tissue collected from background locations.

[3] "Background area" means a habitat similar to the habitat being assessed, but one that is outside of the influence of the site discharge (NJDEP 2012). "Background contamination" means representative contaminant levels in the immediate area of the site that are not attributable to the site discharge itself, and that originate from either natural sources (i.e., not man-made) or off-site discharges (i.e., man-made discharges not related to the site). These background contaminant concentrations are generally derived by collecting samples in the background area, avoiding hot spots (NJDEP 2012).



FOIA_07123_0003165_0013

**Cleanup levels,** or final **remediation goals (RGs),** are defined under CERCLA guidance as the concentration of a hazardous substance in an environmental medium determined to be protective of human health and the environment under specified exposure conditions (USEPA 1999). Cleanup levels/RGs represent concentrations of contaminants of concern (COCs) in environmental media and are required under CERCLA for each COC, receptor, and exposure pathway identified in the human health and ecological risk assessments. Final cleanup levels are prescribed in the record of decision (ROD).

The overall integration of RAOs, preliminary remediation goals (PRGs), and remedial action levels (RALs) will be further developed in the preparation of the FS, incorporating available data in an iterative process, culminating in the presentation of final cleanup levels in the ROD.

**COPCs** are identified in the risk assessments using a multistep screening process that is intended to distinguish between: (1) chemicals that pose negligible risks and can be eliminated from further evaluation, and (2) chemicals that warrant further evaluation of their potential to pose unacceptable risk to humans and/or ecological receptors (i.e., COPCs). All COPCs identified as a result of the screening process are evaluated in the baseline HHRA and BERA to identify those COPCs that are significant contributors to site-related risks. Ecological COPCs are also referred to as contaminants of potential ecological concern.

**COCs** are a defined as a subset of the COPCs that are identified in the RI/FS as needing to be addressed by the response action. COCs will be identified in the FS and will be the focus of the remedy. The terms "contaminant of concern" and "chemical of concern" are synonymous under CERCLA (USEPA 1988, 2001, 2002b).

**Practical quantitation limit (PQL)** refers to the practical quantitation limit for a chemical concentration reported from a laboratory analysis and is generally equivalent in meaning to the terms quantitation limit and reporting limit. The NCP (40 CFR § 300.430(e)(2)(i)(A)(3)) allows that cleanup levels be modified based on "factors related to technical limitations such as detection/quantification limits for contaminants."

**Point concentrations** are chemical concentrations in sediments at a given sampling location. Point concentrations are typically applied to small exposure areas (e.g., benthic organisms with small home ranges). Point concentrations usually pertain to smaller-scale management areas for the protection of benthic communities.

**PRGs** specify the estimated endpoint concentrations or risk levels for each exposure pathway that are believed to provide adequate protection of human health and the environment, and comply with ARARs, based on available site information (USEPA 1991c,d, 1997). For the FS, PRGs will be expressed as sediment concentrations for the risk drivers, and will be established considering risk-based threshold concentration (RBTCs), ARARs, background concentrations, and PQLs.



FOIA_07123_0003165_0014

**RAOs** provide a general description of what the proposed remedial or response action is expected to accomplish to address the risks posed by the site (USEPA 1999, 2005). They are narrative statements of the medium-specific or area-specific goals for protecting human health and the environment. RAOs are used to help focus development and evaluation of remedial alternatives. RAOs are derived from the risk assessments and are based on the exposure pathways and receptors and the identified COCs. Narrative RAOs form the basis for establishing PRGs.

**RALs** are chemical-specific sediment concentrations that are used to delineate areas where active remedial measures (e.g., dredging or capping) will be undertaken under a given remedial alternative. RALs are not the same as PRGs or RGs, which define the ultimate risk-reduction or ARAR-based goals to be achieved by the remedial action, and which are not always expressed as sediment concentration goals. RALs may differ among various remedial alternatives, reflecting different tradeoffs among considerations of immediate risk reduction, longer-term recovery, remedy scale and implementability, and cost. RALs also may differ among different areas of a site, depending on the magnitude and type of risk to be addressed, land use, and the expected rate of future natural recovery.

**RBTCs** are concentrations of COCs in environmental media estimated to be protective of humans and ecological receptors, derived using risk levels (or ranges) considered by EPA to be acceptable using site-specific exposure scenarios other site-specific methods and assumptions for quantifying risk established in the baseline HHRA and BERA. As such, RBTCs provide a means to evaluate risk management efforts to reduce or eliminate pathways of exposure to COCs that result in estimated risks that are higher than levels considered acceptable by EPA. RBTCs are used, along with other site information, to set PRGs in the FS. RBTCs may be expressed as either point concentrations or surface area-weighted average concentrations (SWACs).

**Risk drivers** are used in the FS to identify a subset of COCs that contribute most significantly to site-related risks. EPA risk assessment policy states that one of the key goals of the risk assessment is to identify the chemicals and pathways that pose the majority of the site risk. Risk drivers are used in the FS to identify contaminant-specific PRGs and RALs that define the scope of remedial actions under each remedial alternative, and the target concentrations that the remedial action is intended to accomplish. Conceptually, risk drivers are similar to "indicator chemicals" defined in EPA guidance for the RI/FS process (USEPA 1988), which specifies that "[i]ndicator chemicals are chosen to represent the most toxic, persistent, and/or mobile substances among those identified that are likely to significantly contribute to the overall risk posed by the site." Other COCs not designated as risk drivers will be addressed in the FS by estimating the potential risk reduction associated with these COCs following remedial actions.

**SWACs** are similar to a simple arithmetic average of point concentrations over a defined area, except that each individual concentration value is weighted in proportion to the sediment area it represents, thereby removing the influence of spatially biased sampling. SWACs are widely used in sediment management and are integral to the determination and application of sediment cleanup levels. The selected area over which a SWAC is applied may be adjusted for a specific receptor or activity. For example, river-wide SWACs may be appropriate for estimating risks attributable to human consumption of fish or shellfish that range over wide areas. SWACs may also be calculated for smaller exposure areas, as appropriate, for a specific receptor or activity. In this manner, site-wide or area-wide SWACs are intended to provide meaningful estimates of exposure point concentrations for either human or wildlife receptors.

**Target areas** are candidate areas that will be identified within the FS for active sediment remedial measures (e.g., dredging, capping, *in situ* treatment, and/or enhanced natural recovery [ENR]) under one or more of the remedial alternatives. Target areas, by definition, include mappable areas of the sediment bed that exceed RALs established for a given remedial alternative. A variety of mapping techniques is available to delineate the footprints of the target areas.

### 1.2.2 Feasibility Study Data Sets and Information Sources

Several elements of the RI/FS program will provide data and information to support the FS, including environmental characterization data collected and compiled in the RI and conceptual site model (CSM); the results of the baseline human health risk assessment and BERA; and the output of the hydrodynamic, sediment transport, contaminant fate and transport, and bioaccumulation models; and treatability studies.

The baseline data sets for the FS were collected during the LPRSA RI between 2008 and 2013 (Table 1-1). In addition to the RI data, some of the data collected by others and prior to the initiation of the LPRSA RI will be used to support FS evaluations. Four major sediment sampling programs were performed as part of the RI, with samples collected at approximately 450 locations.

1. The 2008 Low-Resolution Coring (LRC) program cores were advanced to native material or refusal (AECOM 2011b)
2. 2009/2010 Benthic sediment grab program included collection of surficial (0- to 6-in.) grab samples (Windward 2011d)
3. 2012 LRC Supplemental Sampling Programs (SSP) cores were advanced to a depth of 2.5 ft (AECOM 2013b)
4. 2013 LRC SSP2 included a combination of surficial grabs and cores that were advanced to native material or refusal (AECOM [in prep.]-c).

All samples were analyzed for a full suite of COPCs (i.e., polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans [PCDDs/PCDFs], PCBs, pesticides, polycyclic aromatic hydrocarbons [PAHs], and metals) and physical parameters (grain size, total organic carbon, and percent moisture). Surficial samples were analyzed for volatile organic compounds (VOCs) and acid-volatile sulfide/simultaneously extracted metals, and the LRC samples were analyzed for radiochemical data (cesium-137 and lead-210).

There are several additional sediment data sets that were not collected by as part of the LPRSA RI, but that will support the FS evaluations (Table 1-2). These data include the cores from the RM 10.9 investigation (2011/2012; low resolution cores analyzed for the suite of COPCs and high resolution cores analyzed for radiochemical parameters), the Lister Avenue Joint Defense Group sediment cores (2011), the EPA empirical mass balance model sediment cores (2007), the five EPA high-resolution cores (2006), and the 99 Tierra low-resolution cores (1995) collected between RM 1 and 6, advanced to native material.

Ecological data, including tissue sampling, toxicity analyses, and avian and habitat surveys were collected as part of the RI to support the risk assessments. In addition to these data, older tissue data, collected by EPA and Tierra prior to the initiation of the RI, were used to characterize temporal changes in tissue concentration in the LPRSA.

A series of five bathymetry surveys was performed between 2007 and 2012 to support the RI; these surveys were performed using the same methodology and equipment each time (to the extent practicable) to provide a set of comparable data. Depth-difference maps were calculated from paired surveys; these data are used to assess changes in bathymetry greater than ± 0.3 m (AECOM 2010a). These data support contaminant mapping and sediment stability evaluations. The following historical bathymetry data were also used to support sediment stability and surface mapping evaluations:

- 1949 USACE post-dredging survey
- 1966 USACE conditions survey
- 1995 Tierra bathymetry survey.

The 1949 and 1966 data were digitized and georeferenced from available survey maps. The 1995 single-beam survey was performed in RM 1 to 7 by Tierra as part of the initial RI.

Paragraph 37.i of the AOC and Section F.5 of the statement of work (SOW) state that the FS is anticipated to include the identification of candidate remediation technologies for evaluation in a treatability study program, followed by the implementation and documentation of those treatability studies in a series of interim technical memoranda and other deliverables. In the time since the AOC was signed in 2007, the substantive treatability study requirements of the AOC and SOW have been met through bench-scale tests, pilot tests, and removal actions undertaken to date by EPA and its Partner Agencies, the CPG, and TMO. These are documented as follows:

- Draft Source Control, Early Action Focused Feasibility Study, Lower Passaic River Restoration Project. Prepared for U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, New Jersey Department of Transportation. Malcolm Pirnie Inc. June 2007
- Cement-Lock® Technology for Decontaminating Dredged Estuarine Sediments. Gas Technology Institute. November 2008
- Demonstration Testing and Full-scale Operation of the BioGenesis℠ Sediment Decontamination Process: Final Report. BioGenesis Washing BGW, LLC, Springfield, VA. December 2009
- Environmental Dredging Pilot Study Report—Lower Passaic River Restoration Project. Prepared for U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, New Jersey Department of Transportation. Louis Berger Group. July 2012
- River Mile 10.9 Removal Action—Sediment Washing Bench-scale Testing Report, Lower Passaic River Study Area—CERCLA Docket No.02-2012-2015. CH2M Hill, Inc. 2012
- Final Construction Report–Lower Passaic River Study Area–Phase 1 Removal Action, Tierra Solutions, Inc. March 2013
- River Mile 10.9 Removal Action, Final Design Report, Lower Passaic River Study Area. CH2M Hill, Inc. July 2013.

A summary of the findings from these activities and their bearing on the development and evaluation of remedial alternatives for the LPRSA will be incorporated into the FS.

### 1.2.3 Feasibility Study Activities

Activities specific to preparing the FS will include:

- Summarizing the current site conditions by presenting and evaluating the results of the RI, the CSM, the baseline HHRA and BERA, and related documents
- Identifying ARARs and other regulatory, policy-based, and/or administrative factors to be considered (TBCs)
- Establishing RAOs and PRGs, taking into account RBTCs, ARARs, and regional background levels of COCs in relevant environmental media
- Applying the hydrodynamic, sediment transport, contaminant fate and transport, and bioaccumulation models developed in the RI/FS to project future sediment and tissue recovery under different remedial alternatives
- Estimating volumes and areas of surficial sediment with concentrations of COCs above RALs

- Identifying and screening general response actions (GRAs), remedial technology types, and specific process options best suited to site conditions
- Assembling the technology types and process options into site-wide remedial alternatives, and completing the screening and final assembly of site-wide remedial alternatives
- Identifying candidate technologies for potential treatability studies and pilot studies, and implementing and evaluating the results of these studies
- Completing a detailed evaluation and comparative analysis of remedial alternatives, concluding with a recommended preferred remedy.

Many of these activities, while shown as sequential steps, will be conducted in parallel. The FS will also build on activities completed to date, including the RM 10.9 removal action, the preliminary screening evaluations performed as part of the EPA FFS (MPI 2007b), and treatability and pilot studies performed by EPA (MPI 2007b; USEPA 2012a; BioGenesis 2009; GTI 2008) and the CPG (CH2M Hill 2012a,b).

### 1.2.4 USEPA Sediment Guidance Guiding the LPRSA FS

The EPA Sediment Guidance identifies critical considerations for effectively conducting the FS process at contaminated sediment sites (USEPA 2005). The document supplements existing EPA guidance by offering sediment-specific guidance on critical issues, including numerical modeling, development of remedial alternatives, application of the NCP remedy selection criteria, identification of ARARs, evaluation of effectiveness and permanence, cost estimation, and use of institutional controls.

Several challenges described in the EPA Sediment Guidance associated with contaminated sediment sites are particularly applicable to the FS for the LPRSA:

- Sediment sites may have a large number of sources, some of which can be ongoing and difficult to control. In the LPRSA, upstream and downstream sources (caused by tides) and tributaries have the potential to impact the selection and effectiveness of remedial actions.
- Sediment environments are dynamic. Tidal action, storm surge, and changes in river flows, as well as navigational dredging and urbanization, represent the changing natural and anthropogenic factors that have affected the LPRSA in the past and continue to do so today.
- Cleanup work in an aquatic environment is difficult and costly. Active measures such as dredging and capping in the LPRSA will present significant challenges and costs. Furthermore, the dynamic nature of the river can result in the resuspension of sediment during remediation, which can present short-term risk and affect the remedy.

- The LPRSA is considered a "megasite" and is both very large and very complex. For more than 200 years, there have been myriad chemicals and contaminants released to the LPR from numerous industrial and municipal sources. Within the watershed are numerous non-Hazardous Substance List stressors and potential sources of contaminants to the LPR, as well as the aggregate impacts of years of industrial and urban discharges to the river system.

In addition, the urban setting of the LPRSA introduces a range of challenges and constraints to remedial implementation. Primary constraints include:

- Numerous low clearance bridge crossings, coupled with high uncertainty about the condition, availability, and ability of bridges to be opened frequently throughout the multi-year construction time frame, will impact dredging and capping production rates.
- Upland transportation infrastructure will be stressed by barge and truck activity required to transport dredged sediment and capping/backfill materials. These impacts on the upland transportation network may be compounded by delays associated with the bridge openings required for barge traffic. The capacity of the existing rail system is uncertain and may be a rate limiting factor, potentially delaying and extending the duration of the cleanup.
- Numerous utility crossings, bridge abutments, and dilapidated shoreline structures (bulkheads, piers) will constrain dredging and capping activities. Management of these constraints will require development of safe offsets and/or engineering controls to avoid damage to infrastructure. Dredging and capping may not be achievable in some areas.
- Water depth limitations, low bridge crossing, and navigational constraints will restrict the size of equipment that can be used within the river.

The guidance also recognizes that combined approaches to cleanup are more likely to meet with success, citing examples such as the use of armored capping for erosional areas, together with thin layer capping ENR, and monitored natural recovery (MNR) in other areas, and appropriate institutional controls. Combined approaches will be considered in the development of remedial alternatives for the LPRSA FS.

Finally, in recognition of the challenges and uncertainties that accompany large-scale sediment remediation, the guidance emphasizes that flexibility should be built into the selected remedy: "Iterative or adaptive approaches to site management are likely to be appropriate at these sites." EPA has recently reemphasized and heightened the focus on adaptive management as an effective approach to cleanup of large, complex sediment sites ( USEPA 2013). As part of a comprehensive review of the Superfund program to evaluate the efficiency of the cleanup process and the effective use of resources, EPA has identified adaptive management as a significant element of the Superfund Remedial Program Review Action Plan: "While some aspects of adaptive management were used historically, this plan emphasizes integrating it



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more deliberately throughout the remedial process" (USEPA 2013). The complex nature of the LPRSA and the potential need for large-scale active remediation to achieve cleanup goals suggest that an adaptive management approach could be well-suited to this site.

### 1.2.5 Remedy Selection

The FS will identify and screen remedial technologies based on the general range of LPR sediment characteristics, waterway conditions, and the COCs identified in the risk assessments. Detailed analyses will be performed on remedial alternatives developed from these technologies, and ultimately provide the information necessary to identify a preferred remedial action. After the FS is finalized, EPA will issue a proposed plan for public review and comment. The proposed plan will summarize the results of the FS and describe the basis for EPA's selection of a preferred alternative. After comments on the proposed plan have been evaluated and addressed, EPA will issue a ROD that documents the selected cleanup plan and the basis for its selection.

## 1.3 Document Organization

The remainder of this document comprises the following sections, which reflect the FSWP outline referenced in the Settlement Agreement:

- Section 2 provides a description of the LPRSA and a summary of the Interim CSM.
- Section 3 presents the approach to developing RAOs, PRGs, and metrics to evaluate the remedial alternatives.
- Section 4 presents the process for identifying and screening remedial technologies.
- Section 5 provides the approach for developing remedial alternatives.
- Section 6 presents the process for screening remedial alternatives.
- Section 7 presents the approach for the detailed and comparative analysis of the remedial alternatives.
- Section 8 describes the FS reporting and proposed schedule.
- Section 9 contains the references.

# 2 SITE HISTORY AND ENVIRONMENTAL SETTING

This section presents the site history and environmental setting of the LPRSA, and key findings of the Interim CSM.

## 2.1 SITE HISTORY

The LPRSA is located within one of the major centers of the American Industrial Revolution. Early manufacturing was established near Paterson, New Jersey, during the post-colonial era. Beginning with cotton mills, the LPR watershed, concentrated along the river, grew to include manufactured gas plants, petroleum refineries, tanneries, shipbuilding, smelting, pharmaceutical, electronic product, dye, paint, pigment, paper, and chemical manufacturing plants, and other industrial activity (Shear et al. 1996; MPI 2007a; AECOM 2011b). Major population centers such as Paterson and Newark transformed the watershed into a mix of residential, commercial, and industrial uses. Thus, like many other urban systems, the LPR has been subjected to a broad range of contaminant loadings from multiple sources (e.g., untreated industrial and municipal wastewater, combined sewer overflows [CSOs]/stormwater outfalls [SWOs], direct runoff, atmospheric deposition) for a long time. A distinguishing characteristic of the LPR is its elevated levels of 2,3,7,8-TCDD in sediments, which is atypical of most other urban rivers.

Various companies at the 80 and 120 Lister Avenue facilities manufactured chemicals such as pesticides and phenoxy herbicides, including the primary components used to make the military defoliant Agent Orange. Chemical manufacturing and compounding occurred at this location from the 1940s through the 1960s (Bopp et al. 1991, 1998; Chaky 2003; Lillienfeld and Gallo 1989). The Diamond Alkali site, also referred to as the Lister Avenue site, was placed on the National Priorities List (NPL) in September 1984 due to 2,3,7,8-TCDD contamination detected in site soils. Several investigators have since concluded that the Lister Avenue site was the dominant 2,3,7,8-TCDD source to the LPRSA (Bopp et al. 1991, 1998; Chaky 2003; Hansen 2002), and a significant historical DDT source (Bopp et al. 1991, 2006). The Lister Avenue site underwent several remedial actions under the oversight of NJDEP and EPA between 1984 and 2004 (USEPA 2008; Tierra 2008).

Urbanization altered the physical characteristics of the LPRSA. Most tidal marshes, wetlands, and mudflats were filled in or dredged, thus gradually transforming the LPR into a highly channelized river, with the lower 8 miles dominated by hardened shorelines (e.g., sheet pile, riprap, wood pilings; Appendix B; AECOM 2011b; MPI 2007a). New Jersey Route 21—a major State Road—is constructed along the western bank of the LPR. Major historical developments include the completion of the Dundee Dam and lock system in 1858 (AECOM 2011b), and the



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subsequent expansion of regional shipping activities to accommodate growing commercial transportation needs.

A federal navigation channel of varying depth extending from the mouth of the river (RM 0) to the Eighth Street Bridge in Wallington, New Jersey (RM 15.4) was created in the late 19th century (USACE 2010). The navigation channel had four distinct segments with four different authorized depths (USACE 2010):

- 30-ft segment (RM 0 to 2.6). The channel has an authorized depth of 30 ft mean low water (MLW) and is 300 ft wide. The mean tidal range in this segment of the river is 5.5 ft.
- 20-ft segment (RM 2.6 to 7.2). The channel has an authorized constructed depth of 20 ft MLW and is 300 ft wide. From RM 4.1 to 7.2, the channel had the same authorized width and depth; however, the project was constructed to only 16 ft MLW.
- 16-ft segment (RM 7.2 to 8.1). The channel has an authorized constructed depth of 16 ft MLW and is 200 ft wide.
- 10-ft segment (RM 8.1 to 15.4). The channel has an authorized constructed depth of 10 ft MLW and is 150 ft wide.

The channel was subject to numerous deepening and maintenance dredging activities over its first 50 years of existence. No new channel construction was authorized after 1932, but the existing channel was maintained for nearly 50 years (Figure 2-1). The river was busy with traffic during the 1940s, as the height of industrialization and manufacturing on the river coincided with World War II. Post-1950, most of the maintenance dredging focused primarily on the lower 2 miles of the channel. The last maintenance dredging conducted by USACE in 1983 removed more than 500,000 cy of sediment to a depth of 30 ft MLW in the lower 1.9 miles of the channel (USACE 2010).

## 2.2 ENVIRONMENTAL SETTING

The LPRSA has been highly urbanized through the development of residential and urban areas and industrial activities. Changes in the LPR and watershed that accompanied European settlement and industrialization of the area to present day are well-chronicled (Iannuzzi et al. 2002). Most of the tidal marsh, mudflats, shallow nearshore areas, and tidal wetlands historically present in the LPRSA have been either filled or dredged since the 17th century. Today, much of the shoreline in the LPR consists of riprap and sheet pile walls, resulting in a highly channelized river. Upper portions of the LPRSA feature generally steeper and modified shorelines on the west banks with limited areas of riparian vegetation. The east bank is less modified, consisting of more natural shoreline, commercial and light industry, residential areas, and parks.



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## 2.2.1 Physical Setting

The LPR is an integral part of the Greater Newark Bay complex, along with Newark Bay, Hackensack River, Arthur Kill, and Kill Van Kull (Figure 1-1). These water bodies are hydraulically connected through freshwater flows from the rivers to the ocean and by tidal flows that move water both inland and toward the ocean. The tidal flows also connect the Newark Bay Complex to New York Harbor and Raritan Bay (also referred to as the New York/New Jersey Harbor estuary or the Hudson-Raritan estuary).

The LPR extends from the Dundee Dam (RM 17.4) to Newark Bay (RM 0; Figure 2-2). It receives freshwater from the Upper Passaic River at the Dundee Dam, three tributaries (Saddle River, Third River, and Second River), and to a lesser extent smaller tributaries; direct discharges from CSOs, SWOs, permitted municipal and industrial discharges; and direct runoff. Groundwater contribution to the LPR is considered small relative to the freshwater flow that enters the LPR from upstream during average flow conditions (MPI 2007a).

The LPR is a partially mixed estuary with circulation and salinity patterns that are controlled mainly by a dynamic hydraulic balance between the upstream freshwater flow and the downstream brackish tidal inflow from Newark Bay. These flows and their interactions have resulted in the EPA classifying the LPR into three major sections (MPI 2007a; SEI and HQI 2011):

1. RM 17.4 to 10—Freshwater river section (river dominant)
2. RM 10 to 6—Transitional river section (mixed)
3. RM 6 to RM 0—Brackish river section (estuary dominant).

These designations are qualitative—in reality the location of the interface between fresh and saline waters (also referred to as the "salt front") is strongly influenced by the balance between the flow volume of freshwater and tidal flows, as well as the system geometry. The salt front typically moves several miles during each tidal cycle (MPI 2007a; Cañizares et al. 2009; CSM Section 5.1), and can reach as far upstream as approximately RM 14 under extreme low flow conditions (SEI and HQI 2011). The location of the salt front typically coincides with the location of the estuarine turbidity maximum, that is, the region of an estuary with maximum turbidity (Dyer 1995; Chant et al. 2011; CSM Section 5.1, Section 5.2).

The annual average discharge at Little Falls is 1,140 cubic feet per second (cfs) (1,200 cfs at Dundee Dam, based on drainage-area proration). MPI (2007a) determined that all other inflow sources contribute less than 20 percent of the annual average freshwater inflow to the LPR. Peak daily average flows at various statistical recurrence intervals are presented in Table 2-1.[4]

[4] Based on records spanning 1896 to 2012 at the U.S. Geological Survey Little Falls gage station. The record 35,000 cfs event reported in 1903 was affected by a dam failure and, therefore, was not included in the analysis.



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Surficial sediments (delineated from side-scan sonar data [ASI 2006]) were predominantly silts below RM 8, with some silt and sandy areas along the outer bends and in shoal areas (Figure 2–3). Coarse-grained sediments were observed between RM 5.4 and 5.8, where a series of four bridges likely constrict flows and contribute to increased flow velocities and transport of finer grained sediments. Between RM 8 and RM 12.5, the surficial sediments were primarily sand and gravel, with areas of silt observed intermittently in the shoals. Above RM 12.5, the surficial sediments in the channel were silt and sand, with coarser sediments along the shoreline. Gravel, sand, and rock were predominant above RM 14.5. The side-scan sonar delineations of surficial grain size were ground-truthed during the geophysical survey with the collection of surficial sediment samples (ASI 2006), and more recent grain-size observations are also generally consistent with the side-scan sonar mapping.

Land use along the LPRSA varies considerably (Figure 2-4a–c). The lower portion of the river is dominated by high-density commercial and industrial development and rail/transportation infrastructure (Table 2-2). A strip of green space (Riverbank Park and Minish Park) runs along the western bank of the river between RM 4 and RM 5 in Newark. The shoreline along much of the lower 7 miles is bulkheaded. Land use transitions to increasingly commercial and open space upriver, with residential pockets above RM 8. Physical constraints and the primarily industrial/commercial, urban, and infrastructure land uses limit both access and exposure to sediment and surface water in the lower 7 miles.[5] Public access to the western bank between RM 7 and RM 14 is limited by Route 21—a four-lane highway running parallel to the river. The eastern bank of the river between RM 7 and RM 14 has several parks and boathouses. Within the river, mudflats and shallow areas are interspersed along the river (Figure 2-4a–c), with exposed mudflats during low tide and low flow conditions. The potential for exposure to accessible sediment and surface water is greater in the recreational and residential areas above RM 7, where direct access to the eastern banks of the river is possible.

### 2.2.2 Ecological Habitats and Biological Communities

The ecological setting of the LPRSA is typical of urban systems, with reduced habitat quality and increased urban inputs, and has been extensively described previously (Germano & Associates 2005; Iannuzzi et al. 2008; Iannuzzi and Ludwig 2004; Ludwig et al. 2010; Windward and AECOM 2009; Baron 2011). The quality of the ecological habitat has been severely impaired. Non-chemical stressors (e.g., nutrients and organic carbon loads) to the LPRSA ecosystem have had a signification impact on site conditions. The historical and current urbanization, industrial use and residential development of the shoreline (particularly in the lower portion of the LPR) have limited the shoreline habitats. The LPR shoreline can be divided into the following: (1) a lower portion (RM 0 to 8) that is largely characterized by a developed

[5] Accessible sediment is defined as surface sediment beneath 2 ft or less of water at MLW, using USACE nominal MLW of –2.3 ft National Geodetic Vertical Datum 1929 (NGVD 29) (in the Problem Formulation Document [Windward and AECOM 2009]).



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shoreline with structures abutting industrial properties; and (2) an upper portion (RM 8 to 17.4) that is characterized by mixed vegetation abutting roads, parks, and residential properties. Access to the west bank of this stretch of the river is limited by New Jersey State Route 21.

Rapid urbanization within the watershed of the LPR has resulted in extensive habitat loss, namely of wetlands, small tributaries, submerged aquatic vegetation, and emergent woodlands. Furthermore, hydrologic alterations (e.g., dredging) to the LPR and its tributaries have resulted in significant changes to the aquatic vegetated habitat within the LPR (Iannuzzi et al. 2002). The loss of wetlands in particular has likely contributed to declines in the richness of avian and mammalian fauna near the LPR, which is only recently (i.e., since the 1980s) showing signs of recovery (Parsons 1993; Burger 1993). Shoreline habitat is extensively restricted in the LPRSA due to the physical development from urbanization along the banks of the river, particularly in the lower portion of the LPRSA (below RM 7).

Salinity is one of the most important drivers of the environmental setting of the LPRSA, particularly due to the tidal nature of the estuarine zone and transitional waters of brackish salinity. Many species of benthic invertebrates and fish that are found in the LPRSA are excluded from certain portions of the LPRSA because of the salinity gradient; for example, freshwater species are generally found upstream of the head of tide, marine species are found near the mouth of the LPRSA, and estuarine species or those tolerant of brackish salinities (e.g., blue crab) are found throughout much or all of the LPRSA. Salinity tolerances in many species (e.g., American eel) vary by life stage, such that adults may migrate downstream into the estuary, whereas spawning and rearing occurs in freshwater or vice versa.

Turbidity can have various impacts on aquatic habitat, particularly by reducing water quality for aquatic species. For example, Buck (1956) provides a review of the impacts of turbidity on fish productivity in streams, noting that reproduction and growth may be decreased in turbid streams, and that reduced growth may be due to impacted benthic invertebrate species (e.g., sensitive insects). Increased turbidity caused by common carp activity has been directly linked to impacted fish, benthic invertebrates, and aquatic plant communities (Chumchal et al. 2005; Hinojosa-Garro and Zambrano 2004; Zambrano and Hinojosa 1999; Miller and Crowl 2006; Wahl et al. 2011).

Dissolved oxygen was at times depressed in the LPRSA and above Dundee Dam based on the sampling that the CPG conducted (Windward [in prep.]-k). Hypoxia is a stressor that may change the physiology of the benthos. Fish and benthic organisms may have behavioral responses such as avoidance of certain areas, reduced burrowing depths for benthos, metabolic depression and/or growth reduction (Villnäs et al. 2012; Vaquer-Sunyer et al 2008; Diaz and Rosenberg 1995; Riedel et al. 2008).

Sediment profiling imagery taken in 2005 (Germano & Associates 2005) indicated that the LPRSA system is highly enriched by organic inputs such as leaf litter and urban runoff. This



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was confirmed by additional sampling by the CPG. The amount of total organic carbon in the sediment directly influences the benthic community structure and function (Pearson and Rosenberg 1978; Borja et al. 2009; Carvalho et al. 2005, 2011). Nutrients are thought to represent stressors within the LPRSA, and phosphorus has been identified as an aquatic stressor in particular (NJDEP 2008). A TMDL for phosphorus was adopted by NJDEP in 2008 for the freshwater, nontidal portion of the Passaic River basin upstream of Dundee Dam to reduce phosphorus. The benthic invertebrate community, based on the CPG surveys, appears to reside predominantly in the upper few centimeters of the sediment, in the "floc" layer. This layer is largely attributed to general urban input. These organisms are the forage base for fish and other wildlife.

Invasive species also alter both the physical characteristics of the LPRSA and the resulting biological community. There are various invasive or non-native species currently found within the LPRSA that may have impacted native ecosystem and the communities. There are several species that have been intentionally introduced as game fish or to support game fish in New Jersey (Van Clef 2009). Riparian vegetation in the LPRSA includes both native and non-native plant species; only 20 to 29 percent of herbaceous plant species and 60 to 80 percent of shrubs observed along the LPRSA during the 2007 and 2008 vegetation surveys were native species (USACE et al. 2008; Windward 2011e). The primary concern over the introduction of or invasion by non-native species is that native species that are highly adapted to the LPR may not be able to compete for necessary resources with adaptable, non-natives (Carey and Wahl 2010). The result could be localized community disturbance or extinction of sensitive species (Colnar and Landis 2007; Buhle and Ruesink 2009; Jarv et al. 2011; Miller et al. 2010). One non-native species with the potential to impact the LPRSA system is the common carp (*Cyprinus carpio*). Common carp accumulate substantial mass and are widely distributed (from approximately RM 5.5 to 17.4 as well as above Dundee Dam and within the tributaries) (Windward 2010i, 2011a, 2012d). Currently, carp are neither stocked nor managed within the LPRSA.

### 2.2.3 RI Summary

The RI was performed in accordance with the LPRRP work plan (MPI et al. 2005), the LPRRP field sampling plan (FSP; Volume 1) (MPI et al. 2006a), the LPRRP draft FSP (Volume 2) (MPI et al. 2006b), and the 2007 Settlement Agreement and SOW. The RI field investigations were completed in fall 2013, with the completion of the SSP2. Field programs have been documented through a series of data summary and characterization reports (Table 2-3). The RI report is expected to be complete in late 2014. A summary of the RI will be presented in the FS report.

The FSP specified activities to be performed as part of the RI, although not all of the RI tasks were defined in the FSP, and work plans for individual tasks were prepared throughout the project. Two of the tasks originally identified in the LPRRP FSP (MPI et al. 2006a) (pore water and groundwater sampling) were not performed as part of the RI. Porewater sampling was performed as part of the RM 10.9 investigation, and this sampling effort provided data to support the FS evaluations. EPA has also stated to the CPG that it may be undertaking a watershed-scale evaluation of groundwater in the LPRSA jointly with the U.S. Geological Survey.

### 2.2.4 Background Concentrations of COPCs

Although the LPRSA RI/FS focuses primarily on historically contaminated sediment in the LPRSA, it is also important to acknowledge other potential sources of hazardous substances and environmental stressors to the LPRSA from surface water and associated suspended solids that enter the LPRSA from (1) the watershed above Dundee Dam; (2) tributaries to the LPRSA; (3) tidal inputs from Newark Bay; and (4) CSOs, sanitary sewer overflows, and point source discharges, including SWOs. These additional inputs need to be characterized separately from the historically contaminated LPRSA sediment.

EPA guidance recognizes that contamination at a CERCLA site may be due to releases from the site itself and contamination from other sources, including natural and/or anthropogenic sources that are not related to the site under investigation (USEPA 2002). Accordingly, background is a factor that should be considered in risk assessment, risk management, and remedy selection at CERCLA sites. The goal of a background evaluation in the context of an RI/FS is to estimate the levels of COCs that would exist in environmental media at the site in the absence of CERCLA-related releases from the site. The preferred use of reference and background information obtained from representative locations (i.e., those with the same or similar physical, chemical, geological, and biological characteristics but not affected by the activities on the site) is to develop a range of values that can be compared with data collected from within the study area. Background and reference information are not used to negate or subtract from the calculated quantitative site risk estimates. However, understanding the contribution of background concentrations to risks associated with CERCLA releases is expected to be important for refining specific cleanup levels for COCs that warrant remedial action (USEPA 2002).

Regional background concentrations of COCs will be established for sediment, surface water, and tissue in the BERA and baseline HHRA, and will be utilized in the FS to support the derivation of PRGs and the detailed evaluation of remedial alternatives. The identification of proposed reference areas for the LPRSA, procedures for the selection of background data sets, and initial statistical procedures for identifying statistical outliers in background data are described in Appendix B of the Risk Assessment and Risk Characterization Plan (RARC; Windward and AECOM 2013), which is currently undergoing EPA review. Existing regional data sets for surface sediment chemistry, surface water chemistry, and tissue chemistry in freshwater and estuarine areas from Delaware Bay to southern New England are being considered to determine if these data are sufficient and appropriate to define a regional background data set for the LPRSA. These data sources are being evaluated to define regional background consistent with EPA's definition of "constituents or locations that are not influenced by the releases from a site but represent an influence on the site" (USEPA 2002).

## 2.3 CONCEPTUAL SITE MODEL SUMMARY

The development and use of CSMs in environmental investigations conducted under CERCLA and other regulatory programs are well established in guidance documents published by EPA and others (USEPA 1988, 1996a, 1999, 2005, 2006; ASTM 2008). In broad terms, a CSM is a graphical, pictorial, and/or narrative explanatory description of a site that addresses the environmental setting of the site, COC sources and types, the processes that influence COC migration and fate within the environment, and the human and ecological receptors that may become exposed to COCs.

Relevant guidance and accepted practice identify several related applications of a CSM for environmental site investigation, risk assessment, and remedy selection, which include:

- Guiding the design of data collection programs to characterize the nature and extent of contamination, including identifying critical assumptions, uncertainties, and data gaps to be addressed through the site investigation (ASTM 2008; USEPA 1988, 1996a, 2005)
- Integrating available site information into a coherent representation or description of the environmental system under study (USEPA 1996a, 1999, 2005)
- Identifying potential exposure pathways and receptors to support evaluation of risks to humans and ecological receptors (USEPA 1988, ASTM 2008)
- Supporting the identification and evaluation of remedial alternatives (USEPA 1988, 2005).

Accordingly, a CSM typically identifies and describes the following:

- Contaminant sources and release mechanisms
- Contaminant migration, fate, and transport
- Human and ecological receptors, environmental media and COCs, and exposure pathways.

A summary of the major elements of the Interim CSM (CPG 2013) is provided in the following subsections.

### 2.3.1 Contaminant Sources and Release Mechanisms

The LPR has been an effective trap of both sediments and contaminants for the past 60 years. Like many other urban rivers, it has been subjected to a broad range of contaminant loadings



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from a variety of sources (e.g., untreated industrial and municipal wastewater, CSOs/SWOs, direct runoff, atmospheric deposition). These sources discharged directly or indirectly to the LPR or entered via its upstream/downstream boundaries and tributaries from across the New York/New Jersey metropolitan area. Urbanization and industrial development has also severely degraded the habitat quality along the river, resulting in the loss of wetlands, habitat, and a general lack of shoreline vegetation.

As previously described in Section 2.1, several investigators have concluded that the Lister Avenue site was the dominant 2,3,7,8-TCDD source to the LPRSA (Bopp et al. 1991, 1998; Chaky 2003; Hansen 2002), and a significant historical DDT source (Bopp et al. 1991, 2006). 2,3,7,8-TCDD levels in surficial sediments are the major human health risk driver for the LPRSA (MPI 2007b) and also result in potential risks to some ecological receptors. Peak loading for 2,3,7,8-TCDD and most of the other major contaminants appears to have occurred in the early 1960s or earlier, based on core profiles, and declined following the 1972 Federal Water Pollution Control Act amendments.

A central component of the CSM is the effect of ongoing external sources on contaminant distributions. External sources can limit the achievable benefit of active remediation due to the potential for recontamination and will dictate future recovery of the system in the absence of remediation. The data suggest the following:

- Upstream loading at Dundee Dam and downstream loading at Newark Bay likely have the most influence on surface sediment concentrations, with tributaries and CSOs/SWOs playing a more localized role.
- All contaminants except 2,3,7,8-TCDD have concentrations similar to upstream and downstream sources. This may limit the extent to which significant long-term concentration reductions may be achieved by active remediation within the LPRSA in the absence of region-wide source control.

### 2.3.2 Contaminant Migration, Fate, and Transport

The contaminant patterns in LPR sediments reflect physical transport processes and past and present contaminant loadings. Contaminants tend to be associated with finer sediments, with the bulk of the chemical inventory residing in the thick, stable sediment bed of the lower 8 miles and in stable depositional pockets further upstream. The longitudinal distributions of contaminants suggest the following:

- Surface sediment 2,3,7,8-TCDD concentration trends are consistent with a Lister Avenue source and upstream transport up to RM 14.



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- Concentrations of all contaminants except 2,3,7,8-TCDD in LPR sediment are similar to watershed (upstream or tributary) and/or downstream sources (from Newark Bay and beyond).
- Concentration gradients tend to be muted over the lower 12 miles, presumably due to tidal mixing and sediment redistribution processes.

The LPR sediment deposits are largely stable, as suggested by comparisons of bathymetric surveys, sediment core contaminant concentration profiles and radionuclide concentrations, and calculations of scour during high flow events using model and empirical approaches. Bathymetric data sets indicate a net depositional environment with evidence of limited areas of moderate erosion during high-flow events, forming pockets of deeper scour in localized areas often associated with geometric features in the river (e.g., outer bends, obstructions, and channel irregularities).

The system has been recovering since the 1970s from historical dredging and contaminant releases with subsequent sediment deposition and infilling of the LPR. Contaminated sediments have been buried under cleaner, less contaminated sediments and are continually diluted as cleaner sediments deposit and are down-mixed. Burial has slowed as the river has become shallower and the navigation channel has not been maintained; cesium-137 levels suggest that burial slowed in some locations starting in the 1960s, leaving elevated contaminant concentrations at or near the sediment surface. Limited areas have been identified where historically buried contaminated sediments are experiencing periodic erosion and slowing continued recovery. Slowly recovering areas, including mudflats where high contaminant concentrations are detected in the surface sediments, and erosional areas with elevated surficial COPC concentrations, are likely inhibiting natural recovery of the system.

Natural recovery of surface sediment contaminant concentrations has been ongoing over large areas of the LPRSA resulting from burial and mixing of surficial sediments with cleaner, incoming sediments. Some areas in the lower 8 miles that were depositional following the navigational dredging in 1949 but have experienced net erosion since the 1950s and 1960s have shown limited recovery. Natural recovery may slow in the future for the following reasons: (1) concentrations are approaching regional background for many contaminants; (2) the rate of decline in the contaminant-specific regional background is likely decreasing; (3) LPR burial rates are declining; and (4) the importance of the LPR internal contaminant source of 2,3,7,8-TCDD may be increasing as areas not recovering begin to control concentrations on particles depositing in the recovering depositional areas.

### 2.3.3 Risk Receptors and Pathways

This section provides a summary of the ecological and human health risk receptors and pathways. The risk CSMs are presented in the LPRSA CSM (CPG 2013) and will be summarized in the FS.



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#### 2.3.3.1 Ecological

The ecological setting of the LPRSA is typical of urban systems, with reduced habitat quality and increased urban inputs, and has been extensively described previously (Germano & Associates 2005; Iannuzzi et al. 2008; Iannuzzi and Ludwig 2004; Ludwig et al. 2010; Windward and AECOM 2009; Baron 2011). To determine which organisms to assess for potential ecological risk, it is critical to understand the setting and habitat types within and adjacent to the river. The ecological CSM is central to the ecological risk assessment and the ultimate remedy selection.

The quality of the ecological habitat has been severely impaired. The historical and current industrial use and residential development of the shoreline (particularly in the lower portion of the LPR) have limited the shoreline habitats. The LPR shoreline can be divided into the following: (1) a lower portion (RM 0 to 8) that is largely characterized by a developed shoreline with structures abutting industrial properties; and (2) an upper portion (RM 8 to 17.4) that is characterized by mixed vegetation abutting roads, parks, and residential properties. Access to the west bank of this stretch of the river is limited by State Route 21.

**Ecological Receptors**

An EPA-consistent process was used to select preliminary representative receptor species based on the biological surveys and other information (e.g., habitat data) from the LPRSA and the surrounding area. Factors considered in this selection include the following:

- Potential for exposure to contaminated site sediments
- Relative ability to bioaccumulate/biomagnify site-related chemicals
- Societal and cultural significance (including species highly valued by society)
- Ecological significance (including species serving a unique ecological function)
- Sensitivity to site-related chemicals.

The ecological receptor groups for the BERA include the following:

- Zooplankton community
- Benthic invertebrate community (i.e., multiple infaunal species)
- Macroinvertebrate populations (i.e., blue crab)
- Mollusc populations (i.e., ribbed mussel and freshwater mussel)
- Fish populations (i.e., mummichog, banded killifish/darter, white perch, channel catfish/brown bullhead, American eel, and largemouth bass)
- Bird populations (i.e., mallard duck , spotted sandpiper, heron/egret, and belted kingfisher)



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- Mammal populations (i.e., river otter)
- Aquatic plant community
- Amphibian populations
- Reptile populations.

Exposure of ecological receptors to chemicals could be through contact (e.g., direct contact of benthic organisms to sediment), ingestion of water or sediments, or ingestion of contaminated prey. Several of the ecological receptors in the LPRSA utilize the mudflat habitat (e.g., spotted sandpiper). In tidal rivers such as the LPR, intertidal and shallow subtidal areas are an important and productive habitat. Many ecological receptors, including the spotted sandpiper and wading birds, feed primarily along mudflats and other shallow areas. Forage fish, which serve as a food source for larger fish, mammals and birds, also utilize shallow water areas for feeding and refuge. A complete exposure pathway will have a route for a chemical to travel from the source to the ecological receptors and be taken up by them. The potential chemical exposure pathways were evaluated for all receptors to determine which pathways will be evaluated as part of the BERA.

**Assessment and Measurement Endpoints**

The screening level ecological risk assessment, prepared as directed by EPA, has identified numerous contaminants of potential ecological concern, including metals, PAHs, dioxins and furans, PCBs, and pesticides. Assessment endpoints, risk questions, and measurement endpoints will be used to define the evaluation of risks in the BERA. USEPA (1998) defines assessment endpoints as "explicit expressions of the actual environmental value that is to be protected, operationally defined by an ecological entity and its attributes." The BERA for the LPRSA will be based on a community- or population-level assessment and will evaluate the following:

- Maintenance of the zooplankton community that serves as a food base for juvenile fish
- Protection and maintenance (i.e., survival, growth, and reproduction) of the benthic invertebrate community, both as an environmental resource in itself and as one that serves as a forage base for fish and wildlife populations
- Protection and maintenance (i.e., survival, growth, and reproduction) of healthy populations of blue crab and crayfish that serve as a forage base for fish and wildlife populations and as a base for sports fisheries
- Protection and maintenance (i.e., survival, growth, and reproduction) of healthy mollusc populations
- Protection and maintenance (i.e., survival, growth, and reproduction) of omnivorous, invertivorous, and piscivorous fish populations that serve as a forage base for fish and wildlife populations and as a base for sports fisheries



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- Protection and maintenance (i.e., survival, growth, and reproduction ) of herbivorous, omnivorous, sediment-probing, and piscivorous bird populations; use of LPR habitat for breeding used to determine the relative weight for the bird egg measurement endpoint
- Protection and maintenance (i.e., survival, growth, and reproduction) of aquatic mammal population
- Maintenance of healthy aquatic plant populations as a food resource and habitat for fish and wildlife populations
- Protection and maintenance (i.e., survival, growth, and reproduction) of healthy amphibian and reptile populations.

#### 2.3.3.2 Human Health

Human receptors at the LPRSA include recreational anglers, boaters, waders, workers, and residents with properties abutting the river. Transients and homeless individuals have also been observed. These receptors may be exposed to site-related contaminants while engaging in activities that bring them in direct contact with nearshore or mudflat sediments and surface water (i.e., through incidental ingestion or dermal contact). Direct contact with deeper sediments away from the shoreline is not expected to occur under typical exposures and activities on the river. Recreational anglers who do not practice catch-and-release may be exposed to bioaccumulative chemicals like dioxins and furans, PCBs, mercury, and various pesticides from consuming LPRSA fish or crab. Potential exposure via inhalation is negligible given that the dominant contaminants are not volatile.

The presence of bioaccumulative contaminants, including dioxins/furans, PCBs, mercury, and various pesticides, in LPRSA fish and crab has been documented (Windward 2011c). Due to the presence of bioaccumulative contaminants in biota and the creel/angler survey finding that a small percentage of LPRSA anglers consume their catch (AECOM 2013b, [in prep]-d), human health risk is expected to be dominated by consumption of LPRSA fish and crab. The baseline HHRA is currently being performed; however, preliminary data evaluation and a current toxicological understanding of the dominant contaminants suggest that human health risks from consumption of LPRSA fish and crab are driven by 2,3,7,8-TCDD and, to a lesser extent, PCBs, mercury, and pesticides are potential contributors.

The presence of various pathogens (bacteria, protozoa, and viruses) in CSO discharge and LPRSA media has been documented (Exponent 2004; IEC 2003; New Jersey Harbor Dischargers Group 2012; New York-New Jersey Harbor and Estuary Program 2006), and the potential risk to humans from microbial exposures in surface water and sediment has been found to be significant (Donovan et al. 2008a,b). Pathogens, as well as external sources of chemical contaminants present in the LPRSA, influence background conditions that contribute to human health risks.

In summary, for the primary exposure pathways (i.e., direct contact with surface water, direct contact with nearshore/mudflat surface sediment, and ingestion of biota), site-specific factors, including hardened/bulkheaded shoreline throughout much of the lower 6 miles and the western bank; absence of areas conducive to swimming; presence of visible trash, debris, and numerous outfalls; pathogenic contamination; and advisories warning against consumption of all fish and crab throughout the LPRSA, tend to limit human exposures to site-related contaminants.

### 2.3.4 Key Observations and Findings from the Conceptual Site Model

The following summary of elements of the CSM (CPG 2013) describes the important features of the LPRSA:

#### 2.3.4.1 Contaminant Distribution

- The navigation channel of the LPR was historically maintained and large volumes of sediments were dredged from the channel. Dredging of the navigation channel was last performed in 1949 between RM 2 and 8, and in 1983 below RM 2. Above RM 8, dredging was last performed either in the 1930s or the 1970s, depending on river reach. The LPR has been an effective trap of sediment and contaminants for the past century, and particularly since the cessation of dredging.
- The data that have been collected and the analysis of the behavior of the river show that there are specific, predictable locations in the river, such as mudflats and point bars, where sediment containing high concentrations of 2,3,7,8-TCDD has accumulated. There are also limited areas with elevated surficial concentrations of 2,3,7,8-TCDD that have experienced recent erosion. These areas represent potential sources of human and ecological exposure, as well as potential ongoing sources of contamination to the rest of the river, that may be inhibiting natural recovery. These areas also contain other COPCs, including PCBs, DDX, and mercury.
- The areas of highest surface sediment concentration are located in the lower 14 to 15 miles of the river. This is a function of both the sediment type (more fine-grained sediment) and the limit of upstream tidally induced contaminant transport.
- The sediment bed throughout the river is generally stable, and, in many locations, particularly within the navigation channel, the highest COPC concentrations have been buried since their release several decades ago. The stability of the sediment bed is supported by several lines of evidence including vertical contaminant profiles and radiodating. These stable, buried sediments do not pose a risk to human or ecological receptors and are not mobilizing COPCs into the system. In contrast, there are a number of locations, primarily mudflats and point bars, throughout the lower 12 miles of the river where deposition has slowed and steady state conditions were reached on the



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order of 40 to 50 years ago and elevated concentrations of contaminants are found in surface sediment.

- Surficial sediment COPC concentrations are correlated to net sedimentation rates. Lower surficial COPC concentrations are generally observed where net sedimentation rates are higher, and elevated surficial COPC concentrations are generally observed where net sedimentation rates are lower. The latter areas are observed in mudflats above RM 7, and although the sediment and radiochemistry core profiles suggest these areas are generally stable, sediment and bathymetric data suggest that historically deposited sediments are at or near the surface due to limited burial over the last several decades.
- 2,3,7,8-TCDD water column concentration trends are similar to those in the LPR surface sediment data, suggesting that water column concentrations reflect a localized sediment resuspension response (e.g., within a tidal excursion).
- Surficial sediment concentrations of several COPCs tend to be correlated to 2,3,7,8-TCDD surficial sediment concentrations, such that elevated concentrations of other COPCs are observed at the same locations as elevated 2,3,7,8-TCDD concentrations. This relationship is strongest for PCBs and DDx; moderately strong for mercury and other metals and weakest for PAHs. The extent of co-occurrence of COPCs in the sediments is a function of release history as well as chemical behavior.

#### 2.3.4.2 Natural Recovery

- Natural recovery (the reduction in surface sediment concentrations) is seen throughout much of the LPR as surficial sediments are buried by and mix with incoming cleaner sediments from upriver. This natural recovery process is ongoing. Although burial has slowed as infilling has slowed, some areas remain highly depositional and mixing of clean sediment at the surface of the sediment bed is occurring.
- The recovery is most apparent in those locations where the net sedimentation rates are greatest. Recovery is not observed in locations such as the mudflats above RM 7 where there is no significant burial or erosion, and in these locations surficial sediment COPC concentrations remain elevated.
- Fish tissue concentrations have declined in response to recovery of the surficial sediments. Future recovery of surficial sediments can be expected to result in a continued decline in fish tissue concentrations.
- COPCs enter the LPRSA from Newark Bay and over Dundee Dam. The importance of these ongoing sources, with the exception of 2,3,7,8-TCDD, is evident by the similar average surficial sediment concentrations of contaminants other than 2,3,7,8-TCDD within and outside of the LPR. To the extent that COPCs enter the LPRSA from Newark Bay and over Dundee Dam, incoming sediments with higher COPC concentrations than



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those of LPR sediments act as sources to the LPRSA. The extent that recovery can occur in the LPR is controlled by these ongoing sources; remedial actions performed within the LPR cannot reduce COPC concentrations below those of any ongoing sources due to recontamination.

- High flows of the recent past[6] have uncovered previously buried sediments and exposed relatively high COPC concentrations at the surface. Specifically, these areas are net depositional from 1949 (post-dredging) to 2010, but net erosional from 1995 to 2012. These areas now provide a source of contaminated sediments to the rest of the LPR and likely slow natural recovery.

[6] Daily average flow at Little Falls exceeded 13,000 cfs (the 10-year flood) twice in the 47 years from 1949 to 1995 and six times in the 16 years from 1996 to 2011.



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# 3 REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIATION GOALS

RAOs, under the NCP, are established in the RI/FS to specify "contaminants and media of concern, potential exposure pathways, and remediation goals" (40 CFR § 300.430(e)(2)(i)). According to EPA guidance (USEPA 1999, 2005), RAOs "describe what the proposed site cleanup is expected to accomplish." They should be clearly tied to the CSM, address the significant exposure pathways and site-specific risks to human health and the environment, be responsive to ARARs, and provide the basis for more specific PRGs/RGs. RAOs may differ for different parts of a site, regardless of whether such different areas constitute different operable units. RAOs provide a foundational consideration in the process of comparing remedial alternatives and help to focus the development and evaluation of alternatives. RAOs typically evolve over the course of the RI/FS and become final only when the ROD is signed.

The development of RAOs and their role in establishing the basis for setting PRGs/RGs for a site are shaped by several additional specific considerations, including ARARs, RBTCs, background concentrations of COCs in relevant environmental media, and (where applicable) limitations of analytical chemistry data (e.g., laboratory PQLs). These considerations are addressed in the subsections below.

RAOs and the additional considerations described in the subsections below support the development and refinement of PRGs during the RI/FS process, and the selection of final RGs in the ROD. These terms are defined in the NCP and supporting guidance and are used in this document as follows:

- A PRG is a specific identification of a cleanup level (e.g., a sediment concentration or risk level) that is protective of human health and the environment for each exposure pathway. Initially, PRGs may be defined using ARARs or generic cleanup levels, but they are often reevaluated during the RI/FS process as the CSM is refined and site-specific studies, including the baseline HHRA, BERA, and the characterization of background conditions, become available. PRGs may be represented as a range of values corresponding to a risk level or range considered to be acceptable by EPA.
- Final RGs (or final cleanup levels) are established in the ROD and may take into account additional considerations, such as the uncertainty in the risk assessments or models used to characterize the site, and additional factors and tradeoffs (e.g., future site use, remediation time frames, cost-effectiveness, and short-term community and environmental impacts associated with the cleanup) that are identified based on the remedy selection criteria specified under the NCP (40 CFR § 300.430(e)(9)(iii)).



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## 3.1 REMEDIAL ACTION OBJECTIVES

RAOs provide a general description of what the remedy is expected to accomplish. They define the COCs and media to be addressed by the cleanup, address specific exposure pathways and receptors, and provide the basis for defining numerical PRGs. The RAOs and PRGs together support and inform EPA's selection of final remediation goals (or final cleanup levels) in the ROD. The ability of remedial alternatives to attain the RAOs, and the time frame under which RAOs can be met, are primary considerations in the evaluation of remedial alternatives presented in this FS. Finally, RAOs establish how remedy success will be defined and measured after implementation, and provide the basis for determining long-term monitoring requirements.

RAOs and PRGs typically evolve over the course of the RI/FS and become final only when the ROD is signed. The proposed RAOs for the LPRSA are provided below.

- **Human Health—Fish Consumption:** Reduce cancer risks and noncancer health hazards to people who consume fish from the LPR by reducing dietary exposures to 2,3,7,8-TCDD and PCBs
- **Human Health—Direct Contact:** Reduce cancer risks and noncancer health hazards to humans who come into direct contact with LPR sediment and surface water by reducing concentrations of 2,3,7,8-TCDD in sediments
- **Ecological Receptors:** Reduce risks to ecological receptors by reducing the concentrations of ecological risk drivers in LPR sediments.
- **Contaminant Migration:** Reduce potential contaminant migration from the LPR to Newark Bay by addressing the highest concentrations of 2,3,7,8-TCDD in erodible surface sediments.

## 3.2 DERIVATION OF PRELIMINARY REMEDIATON GOALS

PRGs are initial estimates of the endpoint concentrations or risk levels for each RAO that are believed to provide adequate protection of human health and the environment, and comply with ARARs, based on available site information (USEPA 1991c,d; 1997). For the FS, PRGs will be expressed as fish tissue concentrations or sediment concentrations for the risk drivers, depending on the RAO, and will be developed based on consideration of the following factors:

- ARARs
- RBTCs derived from the human health and ecological risk assessments
- Background concentrations, if RBTCs are lower than background concentrations.

Considerations for PRG development and selection involving these factors are described below.



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### 3.2.1 Applicable or Relevant and Appropriate Requirements

CERCLA Section 121(d) requires that remedial actions comply with or waive ARARs, which are defined as any legally applicable or relevant and appropriate standard, requirement, criterion, or limitation under any federal environmental law, or promulgated under any state environmental or facility siting law that is more stringent than the federal law. For this reason, ARARs are a key consideration in the development of RAOs and—in cases where ARARs prescribe binding numeric criteria, standards, or cleanup requirements for environmental media—they can become the basis for establishing numeric PRGs and final cleanup values.

An ARAR may be either "applicable" or "relevant and appropriate," but not both. During implementation of "onsite" CERCLA response actions, substantive but not the administrative requirements of environmental laws and regulations found to be ARARs must be met, or waived in accordance with one of the following six specific conditions per CERCLA Section 121(d) and 40 CFR § 300.430(f)(1)(ii)(C):

1. The alternative is an interim measure and will become part of a total remedial action that will attain the applicable or relevant and appropriate federal or state requirement
2. Compliance with the requirement will result in greater risk to human health and the environment than other alternatives
3. Compliance with the requirement is technically impracticable from an engineering perspective
4. The alternative will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, or limitation through use of another method or approach
5. With respect to a state requirement, the state has not consistently applied, or demonstrated the intention to consistently apply, the promulgated requirement in similar circumstances at other remedial actions within the state
6. For Fund-financed response actions only, an alternative that attains the ARAR will not provide a balance between the need for protection of human health and the environment at the site and the availability of Fund monies to respond to other sites that may present a threat to human health and the environment.

The NCP requires compliance with ARARs during remedial actions as well as at their completion.

TBC criteria are non-promulgated, non-enforceable guidelines or criteria that may be useful for developing a remedial action, or are necessary for evaluating what is protective to human health and/or the environment. Examples of TBC criteria include those in the NJDEP (1997) dredging technical manual and related best management practices.



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ARARs are grouped into three types: chemical-specific, location-specific, and action-specific. Chemical-specific ARARs include laws and requirements that establish health- or risk-based numerical values or methodologies for environmental contaminant concentrations or discharge. Action-specific ARARs are requirements that define acceptable treatment and disposal procedures for hazardous substances. They generally set performance, design, or other similar action-specific controls or restrictions on particular kinds of activities related to managing hazardous substances or pollutants. These requirements are triggered by the remedial activities selected to accomplish a remedy. Location-specific ARARs are requirements that relate to the geographic position of the site. State and federal laws and regulations that apply to the protection of wetlands, construction in floodplains, and protection of endangered species in streams or rivers are examples of location-specific ARARs.

ARARs for remedial alternatives under evaluation for the LPRSA will be compiled and evaluated in the FS report.

### 3.2.2 Risk-Based Threshold Concentrations

An RBTC expresses the maximum concentration of a risk-driver COC that is considered protective of a particular exposure pathway and receptor. RBTCs will be calculated for the risk drivers based on the expo sure assumptions and toxicological parameters used in the risk assessments. Specific calculation methods and the resulting RBTCs will be documented in the draft FS report for each risk-driver COCs. Receptor-specific RBTCs will be derived and presented in the FS report for each risk-driver COC and relevant exposure pathway(s).

### 3.2.3 Background

An evaluation of background chemical concentrations will be presented in the baseline risk assessments. RBTCs will be compared to background as part of the process of identifying actionable levels of COCs (USEPA 2002) and will inform the selection of PRGs.

Consistent with USEPA (2002) guidance on use of background in remediation, PRGs that are below natural or anthropogenic background are generally not used in EPA cleanup decisions. Consequently, in cases where RBTCs for a COC are lower than background, the PRG will be set equal to the background concentration.

## 3.3 PERFORMANCE METRICS

Performance metrics will be developed for use in the FS to evaluate the extent to which each remedial alternative is expected to achieve the RAOs and the time frames, taking into account active remedial measures, institutional controls, and long-term recovery. In general terms, metrics will be based on model simulations to characterize the future sediment, water column



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and tissue concentration both during and after construction, and projections of future residual risk. These projections will be compared to levels needed to achieve PRGs as well as the time frames required to achieve such levels. The evaluation of the proposed RAOs is likely to focus on one or more of the following metrics:

- Short- and long-term projections of surface sediment COC concentrations, which are directly relevant to risk projections for direct contact with sediment and also influence projected fish tissue concentrations.
- Short- and long-term projections of surface water COC concentrations, which are directly relevant to risk projections for human health and ecological surface water direct contact and also influence projected fish tissue concentrations.
- Short- and long-term projections of fish tissue COC concentrations, which are directly relevant to risk projections for human health fish consumption and ecological receptors that consume fish as prey.
- Short- and long-term projections of COC transport from the LPR to Newark Bay, considering both particulate and dissolved-phase loads.

Contaminant fate and transport modeling will be performed to estimate changes in site-wide average sediment and water column concentrations over time for each alternative. Future fish tissue concentrations will be predicted by the bioaccumulation model. The risk projections will be performed in accordance with the procedures specified in the RARC (Windward and AECOM 2013).



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# 4 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

The identification and screening process is a step-wise approach considering GRAs, technology types, and process options that are potentially applicable to cleanup of contaminated sediments in the LPRSA. These three categories or tiers provide a systematic method to identify and evaluate various physical, chemical, and administrative "tools" available for implementing remedial actions.

## 4.1 PRELIMINARY GENERAL RESPONSE ACTIONS

GRAs describe in broad terms the types of actions potentially applicable to cleanup of contaminated media. Each GRA may contain one or more technology type. For example, one GRA is physical removal of contaminated sediments from the site, and two common technologies that can accomplish sediment removal are dredging and excavation. Process options are a further subdivision in the technology screening procedure, and define the specific method or type of equipment used within a technology. For example, dredging may be accomplished using process options such as clamshell dredging or hydraulic dredging.

The GRAs that will likely be considered in the FS include:

- **No Action**—CERCLA guidance and the NCP require the evaluation of a "no-action" response as a baseline for comparing to other alternatives. Under the no-action response, site conditions as defined in the RI, and human health and ecological risks (as identified in the risk assessments), would remain in place, because no remedial action would be implemented.
- **Institutional Controls**—Institutional controls are legal and/or administrative measures, and/or physical site restrictions that limit human use or access to the site, thereby preventing or reducing exposure to COPCs. Fish consumption advisories, waterway use restrictions, deed restrictions, and access restrictions are examples of institutional controls. Institutional controls currently under evaluation for the LPRSA include a fish exchange program and a carp management program.
- **Monitored Natural Recovery**—MNR is a remedy for contaminated sediment that typically relies upon ongoing, naturally occurring processes to contain, destroy, or reduce the bioavailability or toxicity of contaminants in sediment (USEPA 2005). MNR includes regular monitoring such as the periodic collection and analysis of environmental samples (e.g., fish tissue, sediment, surface water) to measure whether human health and ecological risks are reduced to expected levels within an anticipated time frame.

- **Enhanced Natural Recovery**—ENR involves the application of thin layers or particle broadcasting of clean material over areas where natural recovery processes are already occurring to enhance natural recovery. By applying thin layers of clean sediments (i.e., enhanced physical burial) over an area and allowing natural restoration or bioturbation to mix the impacted and clean sediment layers, the natural recovery process is increased and results in a surface layer with contaminant concentrations within acceptable levels. Reactive agents can also be added to the thin layer to enhance natural recovery.
- **Containment**—Containment refers to the in-place physical isolation or immobilization of COPCs in sediment via *in situ* capping. Effective containment can result in rapid limitation of the bioavailability and mobility of COPCs present in the sediments because the underlying COPCs are isolated from biota. The typical process options for containment include capping, capping with partial sediment removal, and reactive caps. Capping may also require controls to limit resuspension during cap placement. In addition to an isolation layer, caps may require an armoring layer to prevent erosion, a habitat layer, and potential other layers.
- **Removal**—Removal refers to the physical dredging or excavation of impacted sediments. Dredging includes the removal of sediment from the site. Dredges are typically classified based on the type of process option such as mechanical or hydraulic removal. Excavation refers to removal of sediments after the water has been diverted or dewatered. Dry excavation includes shoreline and shallow nearshore areas, and can also refer to excavation during low tide conditions. Removal requires consideration of other process options, such as in-water controls to minimize sediment resuspension during removal, dewatering to reduce sediment moisture content, treatment of the water before discharge, transport of sediment, and treatment/disposal of the sediment.
- ***In situ* Treatment**—*In situ* treatment involves the in-place application of biological, chemical, or physical methods for reducing COPC concentrations or COPC bioavailability. *In situ* biological treatment includes the introduction of reagents to enhance the natural biodegradation and mineralization process of the COPCs. Chemical treatment can include oxidation to degrade or destroy the organic COPCs. Physical methods can include solidification or solidification/stabilization, which includes the application of treatment reagents such as Portland cement, pozzolan fly ash, fly ash/Portland cement mixtures, lime kiln dust, or other proprietary reagents.
- ***Ex situ* Treatment**—*Ex situ* treatment involves the biological, chemical, or physical applications of treatment technologies to transform, destroy, or immobilize COPCs following removal of the impacted sediments. Following treatment, the residual materials are typically disposed of in a landfill or, where applicable, used for other beneficial purposes.
- **Ancillary Technologies**—Ancillary technologies can include sediment dewatering, wastewater treatment, and transportation. Dewatering involves the removal of water



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from the removed sediment to produce a material more amenable to handling. Wastewater treatment includes treating the water from the dredged sediment to meet effluent water quality criteria for discharge to a receiving system. The methods for transportation can include combinations of barge, railroad, truck, and pipeline transport.

- **Disposal**—The main technologies for disposal include beneficial use, land disposal, and aquatic disposal. Beneficial use can include in-water beneficial use, upland beneficial use, and incorporation as daily landfill cover. Disposal is the permanent placement of sediment into a permitted and/or appropriate structure or facility. Examples of disposal process options include in-water or near-water facilities such as contained aquatic disposal (CAD) cells or confined disposal facilities (CDFs) and upland and offsite landfills.

Candidate response actions will be screened to eliminate those that cannot be implemented in the LPRSA. The remaining response actions will be further evaluated to identify specific technologies to be included in the development of alternatives.

## 4.2 BENCH-SCALE TESTING AND PILOT STUDIES

Since the initiation of the RI in 2003, several treatability studies have been performed to evaluate candidate remediation technologies for the LPRSA FS by both EPA and its Partner Agencies (BioGenesis 2009; GTI 2008; MPI 2007b; USEPA 2012) and the CPG in support of the RM 10.9 removal action (CH2M Hill 2012a,b).

- Draft Source Control, Early Action Focused Feasibility Study, Lower Passaic River Restoration Project. Prepared for U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, New Jersey Department of Transportation. Malcolm Pirnie Inc. June 2007
- Cement-Lock® Technology for Decontaminating Dredged Estuarine Sediments. Gas Technology Institute. November 2008
- Demonstration Testing and Full-scale Operation of the Biogenesis℠ Sediment Decontamination Process: Final Report. BioGenesis Washing BGW, LLC, Springfield, VA. December 2009
- Environmental Dredging Pilot Study Report – Lower Passaic River Restoration Project. Prepared for U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, New Jersey Department of Transportation. Louis Berger Group. July 2012
- River Mile 10.9 Removal Action – Sediment Washing Bench-scale Testing Report, Lower Passaic River Study Area – CERCLA Docket No.02-2012-2015. CH2M Hill, Inc. 2012
- Final Construction Report – Lower Passaic River Study Area – Phase 1 Removal Action, Tierra Solutions, Inc. March 2013



FOIA_07123_0003165_0045

- River Mile 10.9 Removal Action, Final Design Report, Lower Passaic River Study Area. CH2M Hill, Inc. July 2013
- Carp Harvest Pilot Study Addendum to the Quality Assurance Project Plan: Fish and Decapod Crustacean Tissue Collection for Chemical Analysis and Fish Community Survey. Addendum No. 6, Windward Environmental, September 2013.

These studies provide sufficient basis for evaluation of candidate technologies for the FS, and no additional studies are planned as part of the FS. The FS will include a summary of these studies, and evaluation of the performance of the remedial technologies and the applicability of the results to full scale implementation.

## 4.3 IDENTIFICATION OF DISPOSAL LOCATIONS

A range of disposal options was previously evaluated for the LPRSA in association with the Tierra Phase 1 (Tierra 2008) and RM 10.9 (CH2M Hill 2013) removal actions, and by EPA in the draft FFS (MPI 2007b). Potentially applicable disposal options include permitted offsite landfill facilities, CAD facilities, and CDFs. The findings from prior disposal studies will be evaluated and summarized in the FS and will be considered along information specific to the LPRSA FS, including the volumes and schedule of the remedial alternatives and potential technical and administrative constraints.

## 4.4 IDENTIFICATION AND SCREENING OF CANDIDATE TECHNOLOGIES

The results of the previously completed bench-scale testing and pilot studies will be evaluated together with experience from recent removal actions on the LPRSA and other relevant regional sites to identify candidate technologies to be considered in the FS.

The screening of potentially applicable remedial technologies and process options will consider information from recent regional and national sediment remediation projects. The evaluation and screening of technologies and process options will build directly on EPA's evaluation in the Early Action FFS (MPI 2007b) and subsequent pilot studies/treatability studies performed by EPA (MPI 2007b; USEPA 2012a; BioGenesis 2009; GTI 2008) and the CPG (CH2M Hill 2012a,b). Published guidance and resources such as the Superfund Innovative Technology Evaluation Program, the EPA Hazardous Waste Clean-up Information web site, and the Federal Remediation Technologies Roundtable were also referenced.

In accordance with EPA guidance, the technology screening evaluation will consider effectiveness, implementability, and cost of candidate process options. Effectiveness refers to whether a process option can address the contaminated media types and quantities, support achievement of the RAOs, and is proven and reliable. Implementability refers to whether a process option can be constructed and operated under the physical and chemical conditions of



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the LPR, is commercially available, is administratively feasible, and has been used on sites similar in scale and scope to the LPR. Cost refers to the cost of a process option relative to other process options for a given technology type.

The results of the screening will identify technologies that are retained, retained for consideration during remedial design, and not retained for further consideration. The screening will not preclude reexamination of technologies during the remedial design phase of the cleanup. Rather, the screening will facilitate a streamlined approach to the development and evaluation of remedial alternatives.



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# 5 DEVELOPMENT OF ALTERNATIVES

A set of remedial alternatives will be developed for the LPRSA in a manner consistent with CERCLA guidance (USEPA 1988). The FS will present the rationale, assembly, and description of the alternatives. It is anticipated that there will be a set of engineering elements common to all alternatives, as well as specific evaluations (e.g., delineation of target areas) that will be applicable to a subset of the alternatives.

## 5.1 ENGINEERING ASSUMPTIONS AND CONSTRAINTS

A set of engineering assumptions and technical and administrative considerations applicable to the implementation of the remedial alternatives will be developed. Engineering assumptions will support the development of the remedial alternatives for the following elements:

- Sediment removal
- Material transport, processing, and disposal
- Capping
- MNR/ENR
- Monitoring
- Adaptive management
- Institutional controls
- Navigation and future waterway use
- Habitat considerations
- Sea level rise
- Construction sequencing and constraint
- Early actions.

## 5.2 DEVELOPMENT AND APPLICATION OF REMEDIAL ACTION LEVELS

This section describes the derivation of RALs and their application to delineate target areas that may be actively remediated under one or more of the remedial alternatives that will be developed and evaluated in the FS. At many sites, attaining a final cleanup level will not be achieved solely by active remediation and will rely in whole or part on natural recovery processes occurring over time. There are also circumstances in which cleanup levels can be attained on the basis of a site-wide average or exposure unit average by cleaning up targeted



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areas where concentrations exceed a defined action level. For these reasons, the use of RALs will be considered in the development of remedial alternatives for the LPRSA FS. RALs define levels of contaminants in environmental media above which active remedial measures, such as treatment, capping, or removal, may be implemented.

RALs (defined in Section 1.2.1) differ from PRGs/RGs/cleanup levels, which identify target point or average concentrations to be achieved at the completion of the remedial action. In contrast, RALs define the concentration above which active remedial measures (i.e., dredging or capping) would be taken under a given remedial alternative to reduce concentrations in sediment sufficiently to reach a target risk level (e.g., a PRG) within a specified time frame, taking into account both temporal factors (e.g., natural recovery) and spatial considerations (e.g., relevant risk-based scales of exposure). Conceptually, different areas of the LPRSA may have different RALs depending on the magnitude of risk, rate of natural recovery, and land use. In addition, different RALs may be identified for different types of remedial actions or for different remedial alternatives that will be considered in the LPRSA FS.

RALs will be considered as a basis for defining target areas for active remediation under a given remedial alternative. The applicability of RALs will be explored based on a general optimization method known as "knee of the curve" analysis that explores the progressive reduction in SWAC as a function of incremental reductions in the acres to be remediated, which can be related to candidate RALs for risk drivers (i.e., identifies the point of diminishing returns). This type of analysis, which utilizes graphical methods in which SWAC is plotted again remediated acres, recognizes that the extent of benefit from the target area remediation is a function of the area to be remediated, but at some point the remediation of additional areas provides little additional benefit relative to the increased duration and level of effort.

Target areas, or areas that exceed RALs and will be considered for active remediation, will be identified for one or more of the remedial alternatives. The identification of target areas will be supported by the Interim CSM (CPG 2013) and subsequent updates, which evaluated sediment stability, areas that may be providing ongoing sources of contaminants, and areas that pose the greatest human and ecological risk. The target area boundaries will be delineated by integrating multiple physical and chemical data sets. The FS will present a detailed evaluation of the target area identification and delineation.

## 5.3 METHODS FOR EVALUATING RECOVERY AND RECONTAMINATION POTENTIAL

Natural recovery occurs because of several processes that cause contaminant concentrations in the surface sediment layer to decline. Deposition in the LPRSA introduces particles that typically have a lower concentration than in the surface layer largely because the major sources of new particles are the watershed above the Dundee Dam and Newark Bay, which typically



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exhibit lower concentrations for 2,3,7,8-TCDD and similar or lower concentrations for many other contaminants than are found in the LPR surface sediments. These particles are mixed into the surface sediments (i.e., down-mixed) and reduce concentration by dilution. Sedimentation, which occurs if deposition exceeds erosion, reduces surficial concentrations over time by progressive burial of the higher concentrations. Tidal resuspension of fluff-layer contaminants to the water column provides an additional loss mechanism, although the impact of this flux on recovery may be nominal under normal tidal conditions given the slow exchange processes that transfer contaminants from the parent bed (e.g., diffusion). Likewise, diffusion to the water column from sediment pore water is typically considered a minor factor in surface sediment recovery.

Estimates of rates of natural recovery have been developed through evaluation of sediment COPC concentrations and radiochemical data (CPG 2013). Ongoing and future natural recovery will be evaluated through multiple lines of evidence, including data evaluation and numerical model projections. The FS will present an evaluation of recovery of the LPR to support evaluation of the remedial alternatives that include natural recovery.

The FS will present an evaluation of potential for recontamination of areas where active remedial measures are components of the remedial alternatives. The potential for recontamination is an important consideration in assessing the long-term effectiveness and permanence of active remedial alternatives. Available evidence indicates there are upstream, downstream, and other sources that may limit the achievable benefit of active remediation due to the potential for recontamination from these sources. The recontamination potential evaluation will be based on model predictions of sediment COC concentrations over time due to recontamination that may result from deposition of incoming sediment loads in the remediated areas and resuspension of unremediated sediments. Key uncertainties will be identified and described regarding the extent to which long-term COC concentration reductions may be achieved by active remediation of the LPR in the absence of region-wide source control.

## 5.4 PRINCIPAL THREAT WASTE

The NCP establishes an expectation that EPA will use treatment to address the principal threats posed by a site wherever practicable (NCP § 300.430(a)(1)(iii)). EPA guidance defines principal threat waste as a source material that is highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur, such as drummed waste or pools of nonaqueous-phase liquids (USEPA 1991a). Sediment removed during both the Phase 1 and RM 10.9 removal actions were not identified as principal threat waste, and no direct evidence has been found of nonaqueous-phase liquids in the LPR sediments.



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## 5.5 ASSEMBLING THE REMEDIAL ALTERNATIVES

A set of remedial alternatives that are expected to achieve the RAOs in the LPRSA will be assembled. The alternatives will include a no-further-action alternative, as required by the NCP, and is expected to include alternatives that span a range of areas and volumes to be remediated. Development of the alternatives will also consider a range of candidate technologies and process options that are retained from the technology screening to address contaminated sediments (e.g., removal, capping, ENR, *in situ* treatment, and MNR) and to manage and dispose dredged materials (e.g., stabilization, dewatering, *ex situ* treatment, and disposal).

Additional detail will be developed for each alternative concerning equipment and methods associated with the major remedial approaches (e.g., potential natural recovery processes, stabilization capping, dredging). Alternatives will be described with sufficient detail to allow differentiation between alternative s during their screening (Section 6) and detailed and comparative evaluation (Section 7).

It is anticipated that one or more alternatives will incorporate an adaptive management strategy to address residual risk and the inherent uncertainties involved in a large scale sediment cleanup. Experience at other complex sediment sites points to the value of using adaptive management strategies, as recommended by EPA guidance (USEPA 2005), NRC (2007), and other independent, scientific peer reviews of sediment sites throughout the country (USACE 2008a,b; Cannon 2006). EPA defines adaptive management at Superfund sites as:

> …an iterative approach to site investigation and remedy implementation that provides the opportunity to respond to new information and conditions throughout the lifecycle of a site. Adaptive management assumes there is an explicit intent to respond to new information and conditions, and to the extent it can be done under CERCLA and the NCP site decision making, formal remedial decision documents as well as other project plans and reports incorporate appropriate language that enables efficient planning and execution of adaptive management techniques (USEPA 2013).

This provides for a systematic remedial approach that promotes efficient use of resources and reduces short-term impacts on surrounding communities. Monitoring provides a basis for assessing and determining the need for additional contingency measures if a remedy is performed under an adaptive management framework (USEPA 2005). Adaptive management can assure the success of remedial actions, in that progress is routinely assessed and actions adjusted to reflect up-to-date environmental conditions. If incorporated into a remedy, the adaptive management framework would be based on site-specific conditions and recovery goals.

# 6 SCREENING OF ALTERNATIVES

A range of remedial alternatives will be developed in the FS that combine the various retained technologies in a manner designed to meet project RAOs. The core set of alternatives will be based on the three major approaches for management of contaminated sediments: natural recovery; *in situ* capping; and removal (with treatment or disposal). The alternatives will then be screened to determine which alternatives are carried forward for detailed analysis. The screening process will be consistent with the NCP and as described in EPA's Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA 1988).

The EPA Sediment Guidance describes the methodology for screening remedial alternatives based on estimates of their effectiveness, implementability, and cost:

- **Effectiveness** addresses the ability of an alternative to reliably protect human health and the environment (i.e., to achieve RAOs) over the long-term by reducing the toxicity, mobility, or volume of contaminants.
- **Implementability** encompasses both technical and administrative considerations. An alternative is implementable from a technical standpoint if it can be constructed and operated under site-specific conditions. An alternative is implementable from an administrative standpoint if it can be permitted, constructed, and operated in compliance with regulations. Coordination with other government entities is also considered.
- **Cost**, including both capital and operation and maintenance (O&M) costs, of each alternative is important to the screening process as it enables differentiation between high-cost, low-risk-reduction alternatives and those that achieve comparable risk reduction at lower cost. The cost criteria include an evaluation of the potential range of capital and O&M costs. Consistent with EPA's Guide to Developing and Documenting Cost Estimates during the Feasibility Study (USEPA 2000), the accuracy of an FS cost estimate will range from approximately –50 to +100 percent.

Because of the scale and complexity of the LPRSA, variability in physical characteristics, and a broad distribution of contaminants in the LPR, the development of alternatives will consider the use of adaptive management approaches to the remediation. If an adaptive management approach is used for one or more of the remedial alternatives developed for the FS, it will be necessary for the alternatives definition step to provide a description of the monitoring program that will be implemented to evaluate progress towards achieving RAOs, and the decision making process based on monitoring results.



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# 7 DETAILED AND COMPARATIVE ANALYSIS OF ALTERNATIVES

A detailed analysis of the remedial alternatives for the LPRSA will be performed according to the standard criteria specified by USEPA (1988) and the NCP. A comparative evaluation of the remedial alternatives under CERCLA will be conducted to assess the relative performance of each alternative with respect to evaluation criteria, and to identify key tradeoffs.

## 7.1 FS EVALUATION CRITERIA AND METHODS

USEPA (1988) and the NCP (40 CFR Section 300.430(e)(9)([iii)) require consideration of nine evaluation criteria to address the CERCLA statutory requirements. These nine evaluation criteria are categorized into three sets of criteria that serve as the basis for conducting the detailed analyses and for subsequently selecting an appropriate remedial action.

**Threshold Criteria**

Under CERCLA, each alternative must meet two threshold criteria to be eligible for selection as the preferred alternative.

1. Overall protection of human health and the environment: Addresses the degree to which the alternative achieves and maintains protection of human health and the environment.
2. Compliance with ARARs: Addresses whether the alternative complies with ARARs or if a waiver is justified; and whether the alternative is consistent with other criteria, advisories, and guidance that are to be considered.

**Primary Balancing Criteria**

The NCP establishes five primary balancing criteria that are used, in combination, to weigh effectiveness, implementability, and cost tradeoffs among alternatives. These criteria represent the main technical criteria upon which alternative evaluation is based.

1. Long-term effectiveness and permanence: Addresses the magnitude of residual risk following remedy implementation and the adequacy and reliability of controls.
2. Reduction of toxicity, mobility, and volume through treatment: Addresses (i) the treatment or recycling processes the alternatives employ; (ii) the amount of contaminants that will be destroyed, treated, or recycled; (iii) the degree of expected reduction in toxicity, mobility, or volume; (iv) the degree to which the treatment is

irreversible; ( v)the type and quantity of residuals that will remain; and (vi) the degree to which treatment reduces the inherent hazards posed by principal threats at the site.

3. Short-term effectiveness: Addresses the effects of the alternative during construction/implementation; effectiveness and reliability of protective or mitigative measures; ability to protect the community and workers during construction and the length of time until RAOs are achieved.
4. Implementability: Addresses the ease or difficulty of implementing an alternative given its technical feasibility, administrative feasibility, and availability of services and materials to construct and operate the remedy.
5. Cost: Evaluates the estimated capital and O&M costs associated with the alternative. Cost estimates will be prepared in accordance with the provisions of RI/FS guidance (USEPA 1998) and the cost estimating guide (USEPA 2000).

**Modifying Criteria**

Modifying criteria are state acceptance and community acceptance, which may be used to modify aspects of the preferred alternative when preparing the ROD. Modifying criteria will be evaluated after the FS is released for regulatory and public review, following analysis of public comment on EPA's proposed plan.

1. State acceptance: Considers state positions and/or concerns related to the preferred alternative and other alternatives; and the state's comments on ARARs or the proposed use of waivers.
2. Community acceptance: Considers support, opposition, or concerns expressed by interested members of the community regarding the preferred alternative or other alternatives.

The NCP evaluation criteria are intended to provide a framework for assessing the risks, costs, and benefits for each remedial alternative. In the FS, the relative performance of each alternative will be assessed individually and comparatively with respect to the first seven of the nine CERCLA evaluation criteria to identify the key tradeoffs among them. The last two criteria are considered modifying criteria and are typically assessed by EPA following agency and public comment on the FS in development of EPA's proposed plan.

## 7.2 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

A comparative evaluation of the LPRSA remedial alternatives will be developed to assess the relative performance of each with respect to the CERCLA evaluation criteria and to identify key tradeoffs.



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The alternatives will first be evaluated to assess whether they achieve or do not achieve the two threshold criteria. The alternatives that pass the threshold criteria will then undergo a detailed comparison using the five balancing criteria. Modifying criteria (i.e., state and community acceptance) will not be taken into account in the FS because these criteria will be addressed by EPA in the development of the proposed plan and ROD.



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# 8 REPORTING AND SCHEDULE

The FS deliverables will include a draft and final FS report. In a letter dated January 24, 2014, the CPG requested that EPA modify requirements for interim deliverables specified in paragraph 37 of the AOC (USEPA 2007) and Section F of the associated SOW. The CPG made this request in light of the significant progress that has been made on many key components of the RI/FS since the AOC was executed in 2007, and to support the expedited completion and agency review of the draft FS report. For this work plan, it is assumed that EPA supports this modification, and that interim deliverables will not be submitted, but that regular project updates will be provided to EPA.

## 8.1 DRAFT AND FINAL FS REPORT

In conformance with Section X (USEPA Approval of Plans and Other Submissions) of the Settlement Agreement, a draft FS report will be submitted to EPA for approval. The draft FS report will present the results of the FS tasks described in this work plan and will incorporate key findings of the RI, the risk assessments, modeling, and the treatability studies. After receipt of EPA's comments, the draft FS report will be revised and resubmitted, and may require further revision depending upon state and public comment. EPA will approve the final FS report.

The FS report will consist of the following sections, in accordance with the suggested format described in Table 6-5 of EPA's Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA 1988) and expanded to reflect the current status of the LPRPR RI/FS:

- Section 1 (Introduction) will describe the regulatory setting and FS process.
- Section 2 (Study Area Setting, Remedial Investigation Summary, and Current Conditions) will describe the environmental setting of the LPRSA, summarize the results of the RI, and present a CSM for the LPRSA.
- Section 3 (Summary of Study Area Risks) will provide an overview of the results of the baseline HHRA and BERA.
- Section 4 (Remedial Action Objectives and Preliminary Remediation Goals) will present the proposed RAOs, additional management goals, ARARs, and PRGs for the LPRSA.
- Section 5 (Modeling to Support the Evaluation of Remedial Alternatives) will summarize the technical approach and results of quantitative modeling of hydrodynamics, sediment transport, and contaminant fate and transport, and bioaccumulation in the LPRSA.



FOIA_07123_0003165_0056

- Section 6 (Remedial Action Levels, Target Areas, and Recovery Potential Evaluation) will describe the basis for defining RALs and delineating target areas for active remediation under the remedial alternatives. It will also describe the methods that will used in the FS to evaluate historical natural recovery in the LPRSA, and to project ongoing/future natural recovery under various remedial alternatives, using a combination of empirical lines of evidence and model-based projections.
- Section 7 (Identification and Screening of Remedial Technologies) will describe a broad array of known potential technologies for sediment remediation and disposal and the screening of those technologies to identify representative process options based on site-specific factors.
- Section 8 (Development of Remedial Alternatives) will describe the full remedial alternatives that will be assembled for detailed evaluation based on an integrated consideration of the RAOs, PRGs, RALs, target areas, and the results of the technology screening. A no-action alternative will be included in the evaluation, as required under CERCLA.
- Section 9 (Detailed Evaluation of Remedial Alternatives) will evaluate the remedial alternatives individually against the seven threshold and balancing criteria defined under CERCLA and in accordance with the specific steps and guidelines described in EPA guidance (USEPA 1988).
- Section 10 (Comparative Analysis of Remedial Alternatives) will build on the detailed evaluation of individual alternatives by directly comparing their performance against the seven CERCLA threshold and balancing evaluation criteria.
- Section 11 (Conclusions) will summarize the key findings of the FS.

Supporting analyses may be presented in one or more technical appendices to the FS report.

## 8.2 SCHEDULE

A set of milestone meetings with EPA is proposed to present and discuss key FS assumptions, analyses, and remedial strategies during the development of the draft FS report. Milestone meetings could include:

- RAOs and PRGs
- Technology screening
- Alternatives development
- Alternatives screening.

The proposed submittal date for the draft FS report to EPA is December 3 , 2014.



FOIA_07123_0003165_0057

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# FIGURES

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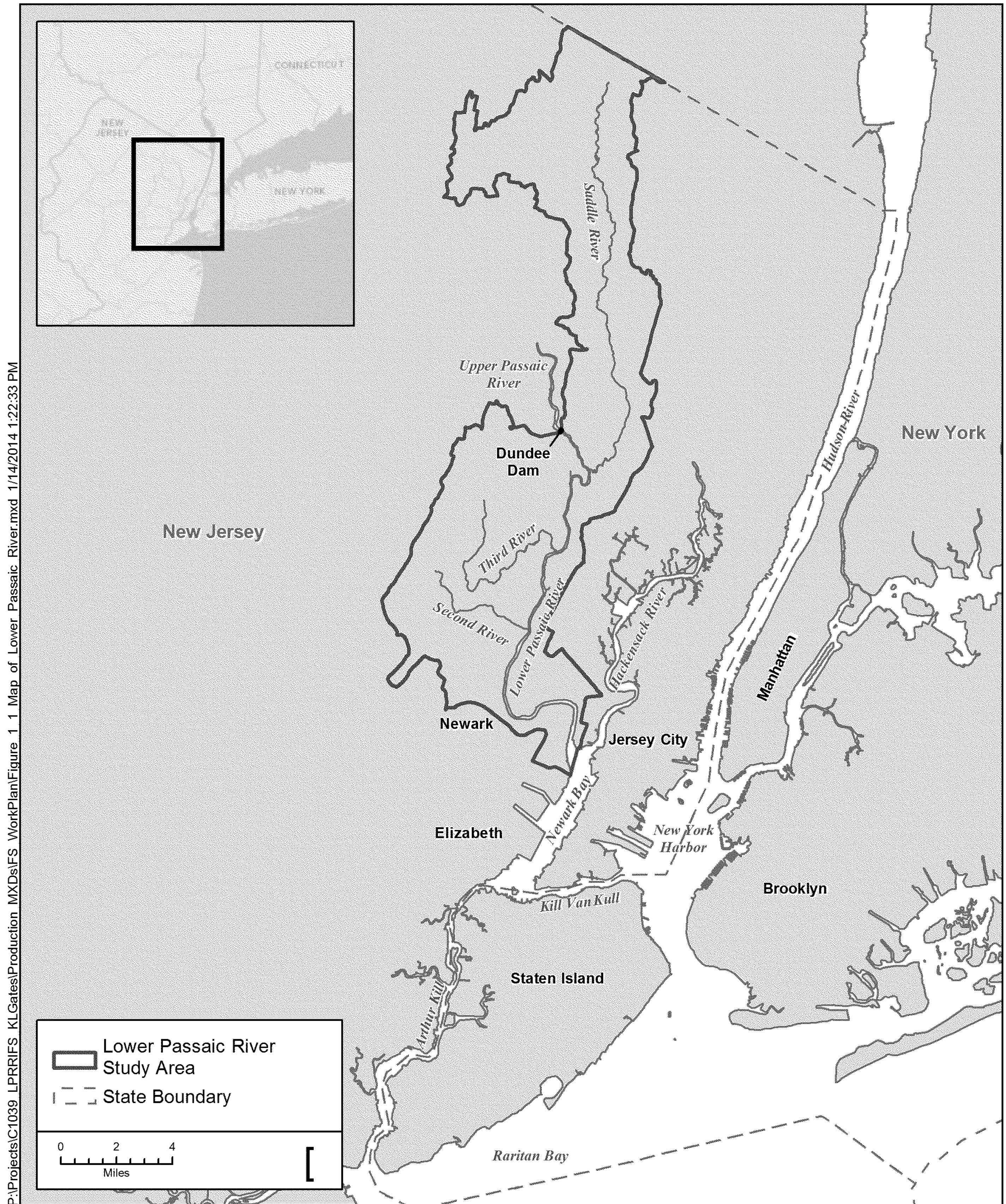


**Figure 1-1.**
Lower Passaic River and Surrounding Regions
Feasibility Study Work Plan, LPRSA RI/FS

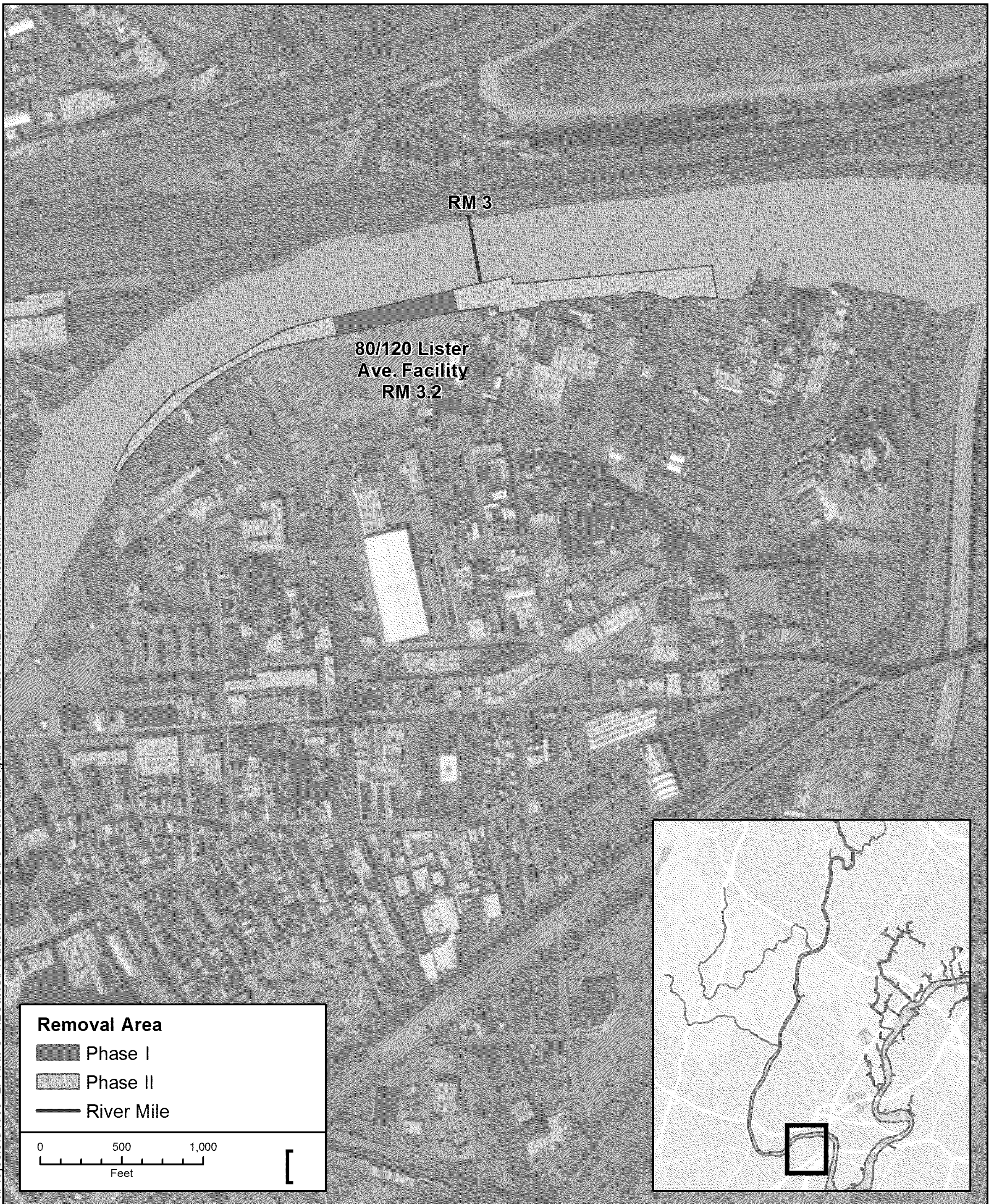


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**Figure 1-2.**
Phase 1 and Phase 2 Removal Action Areas
Feasibility Study Work Plan, LPRSA RI/FS

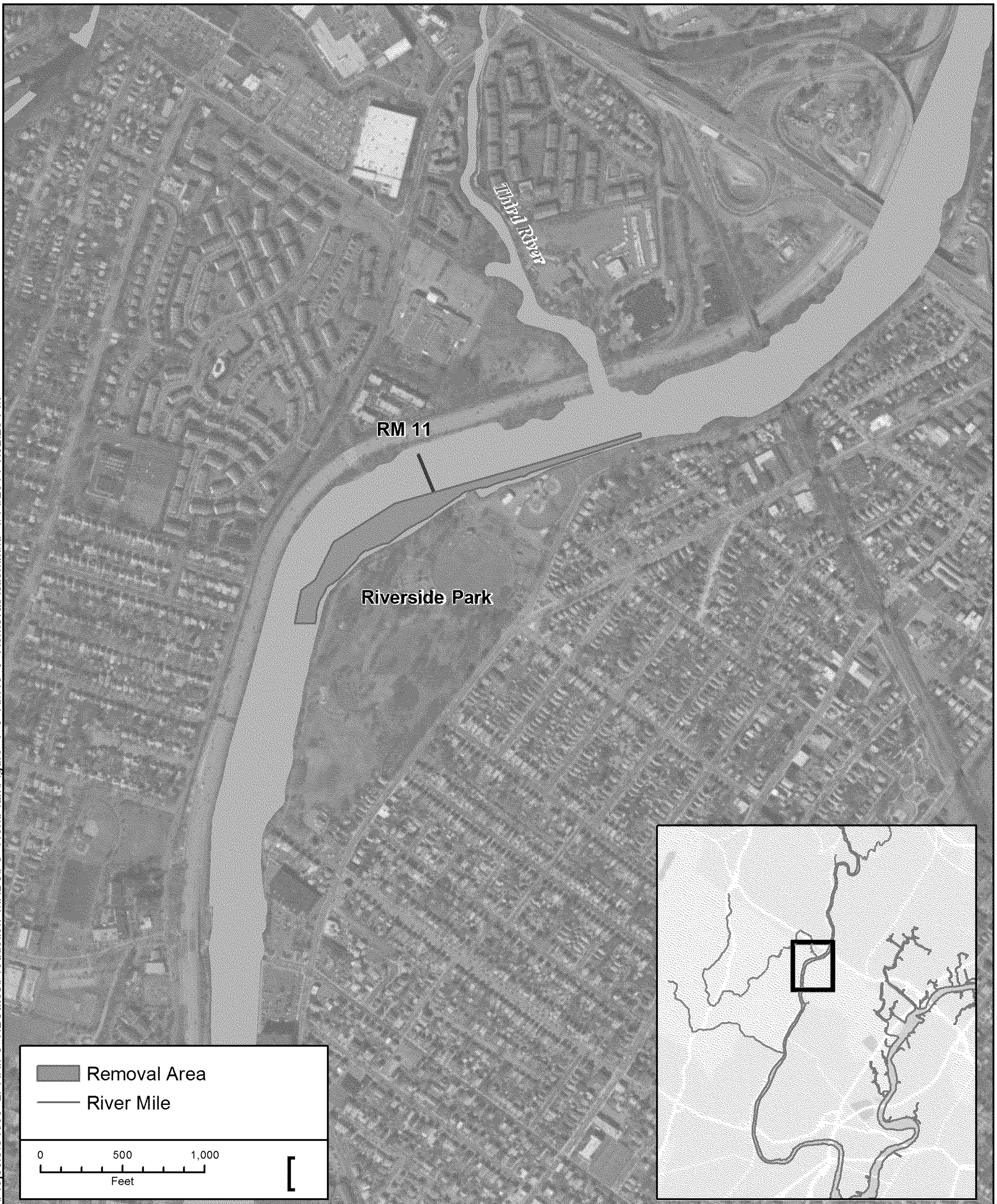


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**Figure 1-3.**
River Mile 10.9 Removal Action Area
Feasibility Study Work Plan, LPRSA RI/FS

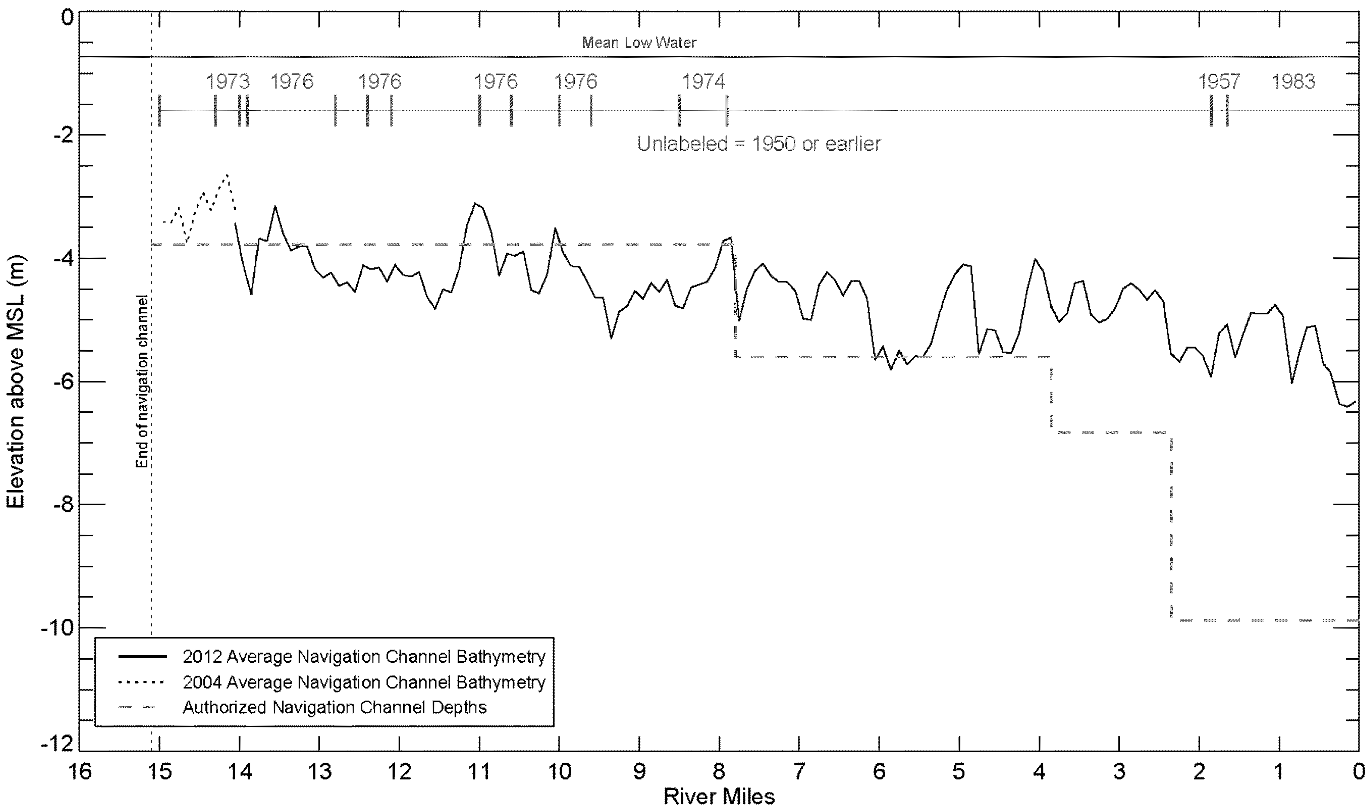


**Figure 2-1.**
Dredging History in the Lower Passaic River and Average Navigation Channel Depth

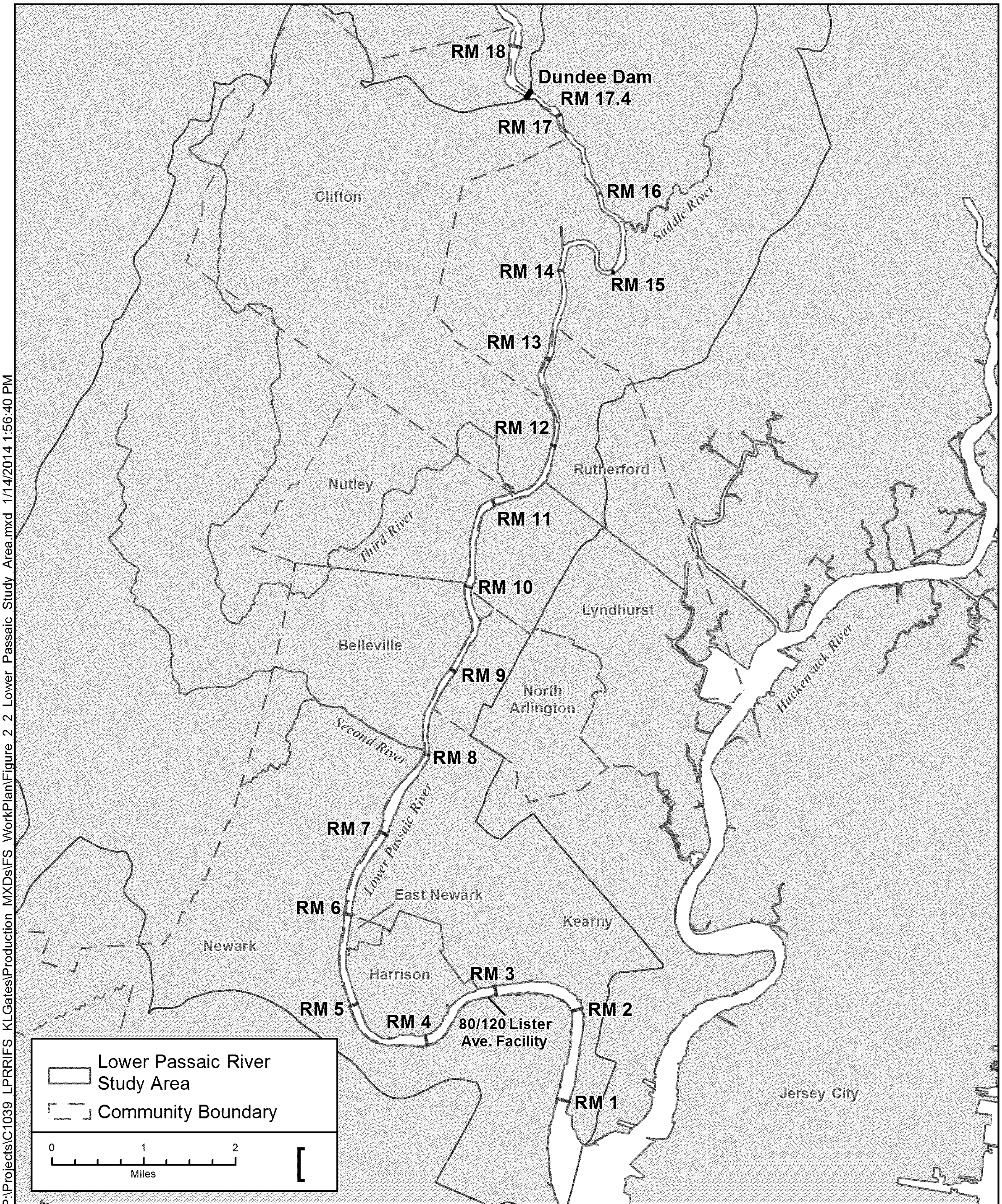


**Figure 2-2.**
Lower Passaic River Study Area
Feasibility Study Work Plan, LPRSA RI/FS

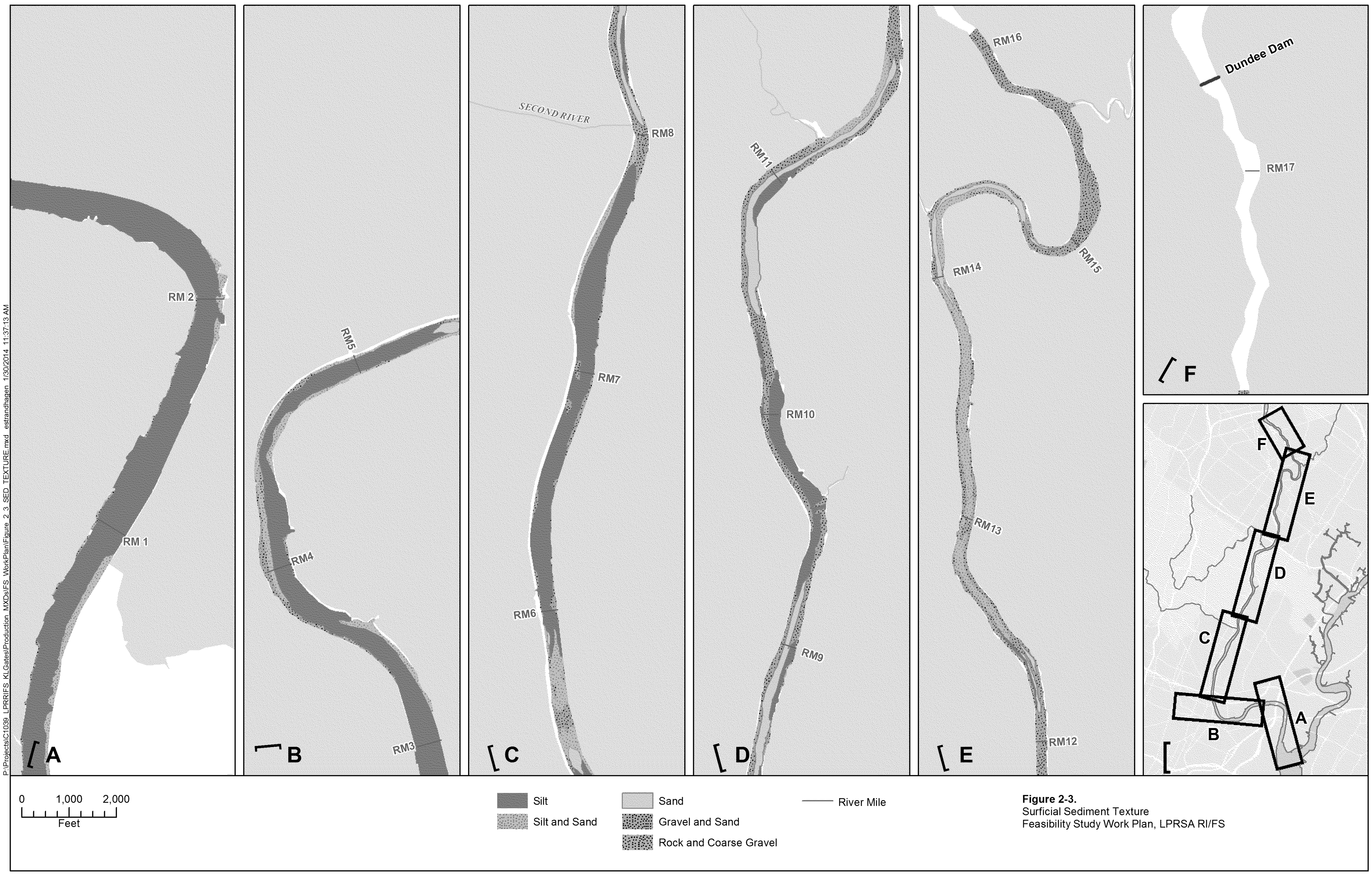


**Figure 2-3.**
Surficial Sediment Texture
Feasibility Study Work Plan, LPRSA RI/FS

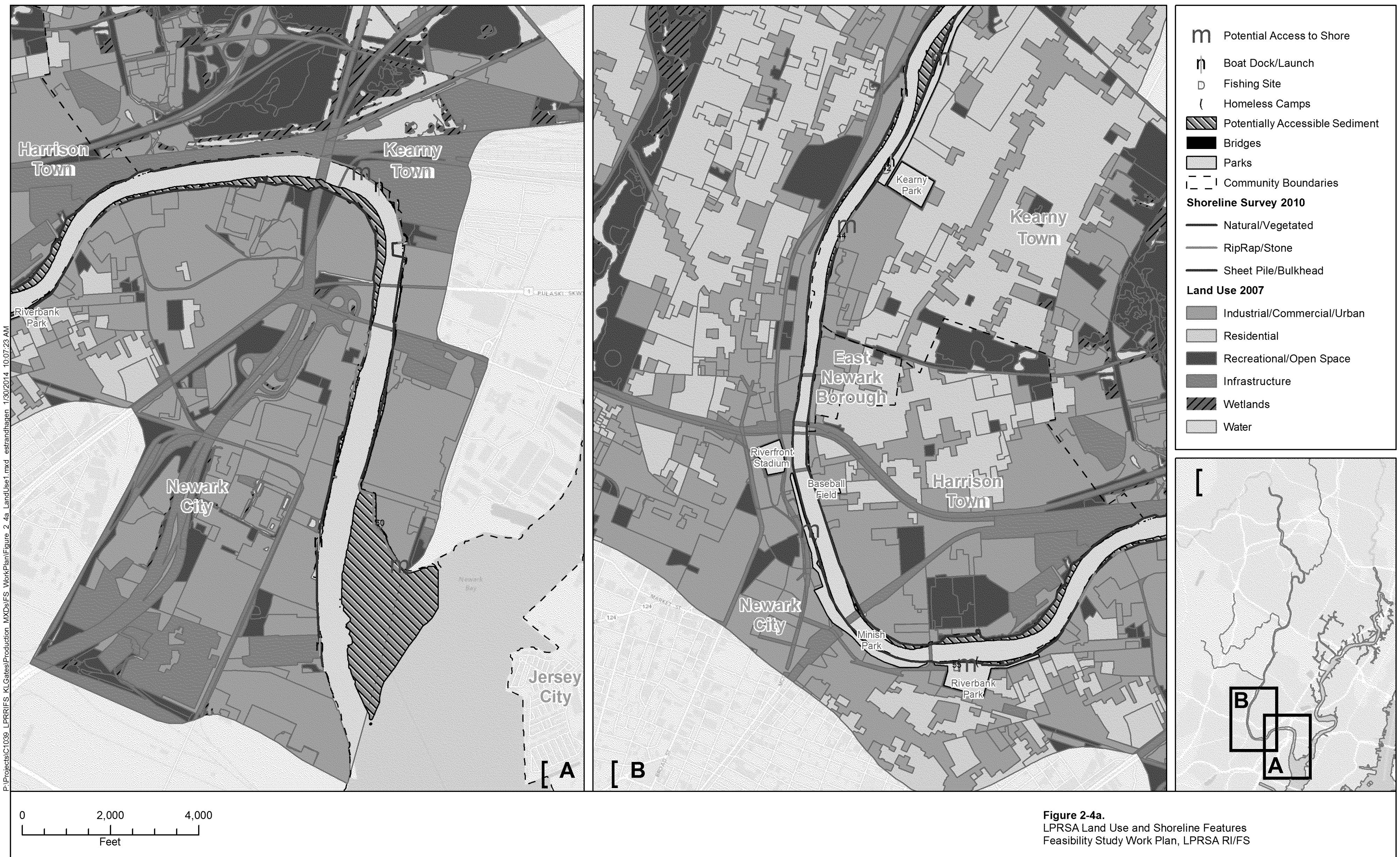


**Figure 2-4a.**
LPRSA Land Use and Shoreline Features
Feasibility Study Work Plan, LPRSA RI/FS


**Figure 2-4b.**
LPRSA Land Use and Shoreline Features
Feasibility Study Work Plan, LPRSA RI/FS


**Figure 2-4c.**
LPRSA Land Use and Shoreline Features
Feasibility Study Work Plan, LPRSA RI/FS

# TABLES

Table 1-1. LPRSA Remedial Investigation/Feasibility Study Data Sets

| Type | Date | Location | Description | Number of Locations |
|---|---|---|---|---|
| **Bathymetry** | | | | |
| CPG Periodic Bathymetry Surveys | September 2007 | RM 0–14 | Single and multibeam | 100-ft single beam transect spacing |
| CPG Periodic Bathymetry Surveys | November 2008 | RM 0–14 | Single and multibeam | 13 single beam transects |
| CPG Periodic Bathymetry Surveys | June 2010 | RM 0–14 | Single and multibeam | 13 single beam transects |
| CPG River Mile 10.9 Field Investigation | July 2011 | RM 10.9 | Single and multibeam | |
| CPG Periodic Bathymetry Surveys | October 2011 | RM 0–14 | Single and multibeam | 13 single beam transects |
| CPG Periodic Bathymetry Surveys | October 2012 | RM 0–14 | Multibeam, single beam in selected shoals | 13 single beam transects and 9 shoal areas |
| **Sediments** | | | | |
| Tierra Solutions, Inc. – 1995 Remedial Investigation Sampling Program | 1995 | RM 1–6.7 | Cores | 100 |
| MPI/Earth Tech – 2004 Sediment Coring for Dredging Pilot Project | July 2004 | RM 2.6–3.1; cores from RM2.9 | Cores | 15 |
| MPI – 2005 Geotechnical Sediment Cores | May 2005 | RM 0–16 (3 cores per transect every mile) | Cores | 51 |
| MPI – 2005 Surface Sediment Grab Sampling Program | August/September 2005 | RM 1–17.4 plus Dundee Lake | Grabs | 34 |
| MPI – 2005 High-Resolution Sediment Coring Program | September/October 2005 | RM 1.05–12.6 (for 5 cores with most analyses) | Cores | 14 |
| MPI – 2006 Low-Resolution Sediment Coring Program | January 2006 | RM 2.9–6.7 | Cores | 10 |
| MPI – 2007 Dundee Lake High-Resolution Coring Program | January 2007 | Dundee Lake | Cores | 4 |
| MPI – 2007 – 2008 Supplemental Coring Program | December 2007 to January 2008 | RM 1–12.6 and Dundee Lake (for surface grabs); RM 8.4–14.47 (for cores) | Cores and grabs | 32 |



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Table 1-1. LPRSA Remedial Investigation/Feasibility Study Data Sets

| Type | Date | Location | Description | Number of Locations |
|---|---|---|---|---|
| MPI – 2008 RM 0 to RM 1 Surface Sediment Sampling | June 2008 | RM 0–1 | Grabs | 18 |
| CPG Low-Resolution Coring (LRC) Program | 2008 | RM 0–17, Tribs, Dundee Lake | Cores and grabs | 109 |
| CPG Benthic Sediment Sampling | 2009/10 | RM 0–17 | Grabs | 132 |
| CPG LRC Supplemental Sampling Program (SSP) | 2011 | RM 0–13.2, Dundee Lake | Cores and grabs | 85 |
| CPG River Mile 10.9 Field Investigation | 2011 | RM 10.9 | Cores and grabs | 60 |
| CPG LRC SSP2 | 2012 | RM 7–14.6 | Cores and grabs | 76 |
| **Surface Water** | | | | |
| CPG Physical Water Column Monitoring Program | 2009/10 | RM 0–13.2, Dundee Lake | Moorings, transect surveys | 6 |
| CPG Chemical Water Column Monitoring Program | 2011–2013 | RM 0–13.2, Dundee Lake | 5 routine events<br>2 high flow events<br>1 low flow event<br>2 high volume events | 6 |
| **Ecological/Tissue Sampling** | | | | |
| Tierrra Solutions RI/ESP Biota Sampling Program | 1999–2001 | RM 1–6.9 | Fish, crab, and mussel tissue | 154 |
| CARP – 2000 – 2004 Harbor Fish/Crustacean Collection | 2000–2004 | RM 2.6 | Fish, crustacean tissue | |
| USEPA – EMAP and REMAP within the National Coastal Assessment – Northeast/New Jersey Coast | 2000, 2002 | NA | Crab and lobster tissue; fish tissue | |
| CPG Tissue Sampling Program | | RM 0–17.4 | 117 blue crab; 281 fish tissue; 19 worm; 10 egg tissue; 10 mussel tissue; 166 animal tissue samples for benthic community assessment | |



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Table 1-1. LPRSA Remedial Investigation/Feasibility Study Data Sets

| Type | Date | Location | Description | Number of Locations |
|---|---|---|---|---|
| CPG Sediment Toxicity Sampling | 2009/2010 | RM 0–17.4 | | 98 |
| CPG Avian and Habitat Surveys | 2010/2011 | | | |
| **Geophysical** | | | | |
| Aqua Surveys Inc. Geophysical Survey | 2005 | RM 0–16 | Side-scan sonar survey, subbottom profiling, magnetometer, shallow pushcores (grain size and TOC), and deep cores (grain size, TOC, Atterberg limits, bulk density, moisture content and percent solids. | NA |
| **Treatability Studies** | | | | |
| EPA Sediment Washing Demonstration Testing (BioGenesis) | 2006/2007 | | Untreated and treated sediments, wastewater sludge | |
| EPA Cement-Lock Pilot Test (Endesco Clean Harbors) | 2006/2007 | | Input and product sediments | |
| CPG River Mile 10.9 Sediment Washing Bench Scale Testing | 2012 | RM 10.9 | Untreated and treated composite bulk sediment samples and wash water | 5 |

Notes:
CARP = Contamination Assessment and Reduction Project
CPG = Cooperating Parties Group
EMAP = Environmental Monitoring and Assessment Program
MPI = Malcolm Pirnie, Inc.
NA = not applicable
REMAP = Regional Environmental Monitoring and Assessment Program
RM = river mile
TOC = total organic carbon

Table 1-2. Supporting Sediment Data Sets

| Data Set |
| --- |
| Post-2000 Honeywell International Sampling Programs |
| 2000 TSI Spring RI-ESP Sampling Program |
| 2000 TSI Toxicity Identification Evaluation Study |
| 2005/2007 TSI Newark Bay Phase I/Phase II |
| 2009 TSI Phase I Geotechnical Assessment |
| 2009 TSI Phase I Sediment Assessment |
| 2011 Lister Avenue JDG |
| 2012 TSI Focused Sediment Investigation |



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Table 2-1. Peak Daily Average Flows at Little Falls

| Recurrence Interval (years) | Discharge at Little Falls (cubic feet per second) |
|---|---|
| 2 | 7,100 |
| 5 | 10,500 |
| 10 | 13,000 |
| 25 | 16,000 |
| 50 | 19,000 |
| 100 | 22,000 |
| 200 | 25,000 |
| 500 | 29,000 |

Table 2-2. Shoreline Land Use along the Lower Passaic River (%)

| Land Use | RM 0–7 | RM 7–17.4 |
|---|---|---|
| Agriculture | 0 | 0.6 |
| Industrial/Commercial/Urban | 72.6 | 32.4 |
| Infrastructure | 16.4 | 22.4 |
| Recreational/Open Space | 10.6 | 33.8 |
| Residential | 0.4 | 10.2 |
| Wetlands | 0 | 0.6 |

Notes:
RM = river mile

Table 2-3. RI QAPPs and Data Characterization Reports

| QAPP | | | Data Report | | |
|---|---|---|---|---|---|
| Document Title | Submittal Date | Reference | Document Title | Original Submittal Date | Reference [a] |
| Quality Assurance Project Plan, RI Low Resolution Coring/Sediment Sampling, Lower Passaic River Restoration Project RI/FS, Rev. 4 | October 2008 | ENSR (2008) | Revised Low Resolution Coring Report | July 26, 2011 | AECOM (2011b) |
| Quality Assurance Project Plan: Fish and Decapod Crustacean Tissue Collection for Chemical Analysis and Fish Community Survey | August 6, 2009 | Windward (2009a) | Fish and Decapod Field Report for the Late Summer/Early Fall 2009 Field Effort | September 14, 2010 | Windward (2010c) |
| | | | 2009 Fish and Blue Crab Tissue Chemistry Data Report for the Lower Passaic River Study Area | September 19, 2011 | Windward ([in prep]-c) |
| Quality Assurance Project Plan: Surface Sediment Chemical Analyses and Benthic Invertebrate Toxicity and Bioaccumulation Testing | October 8, 2009 | Windward (2009b) | Fall 2009 Benthic Invertebrate Community Survey and Benthic Field Data Collection for the Lower Passaic River Study Area | January 6, 2014 | Windward (2014a) |
| | | | Fall 2009 Sediment Toxicity Test Data for the Lower Passaic River Study Area | January 31, 2012 | Windward ([in prep]-l) |
| | | | 2009 and 2010 Sediment Chemistry Data for the Lower Passaic River Study Area | September 2, 2011 | Windward ([in prep]-a) |
| | | | 2009 Bioaccumulation Tissue Chemistry Data for the Lower Passaic River Study Area | September 19, 2011 | Windward ([in prep]-b) |
| Winter 2010 Fish Community Survey Addendum to the Quality Assurance Project Plan: Fish and Decapod Crustacean Tissue Collection for Chemical Analysis and Fish Community Survey. Addendum No. 1 | January 25, 2010 | Windward (2010h) | Fish Community Survey and Tissue Collection Data Report for the Lower Passaic River Study Area 2010 Field Efforts | July 20, 2011 | Windward (2011c) |
| Late Spring/Early Summer 2010 Fish Community Survey. Addendum to the Quality Assurance Project Plan: Fish and Decapod Crustacean Tissue Collection for Chemical Analysis and Fish Community Survey. Addendum No. 3 | June 22, 2010 | Windward (2010e) | | | |
| Quality Assurance Project Plan/Field Sampling Plan Addendum, Remedial Investigation Water Column Monitoring/Physical Data Collection for the Lower Passaic River, Newark Bay, and Wet Weather Monitoring, Rev. 4 | March 2010 | AECOM (2010b) | 2009/2010 Physical Water Column Monitoring Sampling Program Characterization Report | In prep | AECOM ([in prep-e]) |
| Quality Assurance Project Plan, Lower Passaic River Restoration Project, Periodic Bathymetric Surveys, Rev. 2 | May 2010 | AECOM (2010a) | Periodic Bathymetry Survey Report, 2007 Multibeam and Single Beam Bathymetry Survey Report | October 2007 | GBA (2007a,b) |
| | | | Periodic Bathymetry Survey Report, 2008 Multibeam Bathymetry Survey Report | In prep | GBA (2008) |
| | | | Periodic Bathymetry Survey Report, 2010 Multibeam Bathymetry Survey Report | October 20, 2011 | AECOM (2011c) |
| | | | Periodic Bathymetry Survey Report, 2011 Multibeam Bathymetry Survey Report | April 2, 2013 | AECOM (2013c) |
| | | | Periodic Bathymetry Survey Report, 2012 Multibeam Bathymetry Survey Report | April 2, 2013 | AECOM (2013d) |

Table 2-3. RI QAPPs and Data Characterization Reports

| QAPP | | | Data Report | | |
|---|---|---|---|---|---|
| Document Title | Submittal Date | Reference | Document Title | Original Submittal Date | Reference [a] |
| Spring and Summer 2010 Benthic Invertebrate Community Surveys Addendum to the Quality Assurance Project Plan: Surface Sediment Chemical Analyses and Benthic Invertebrate Toxicity and Bioaccumulation Testing. Addendum No. 1 | May 17, 2010 | Windward (2010g) | Spring and Summer 2010 Benthic Invertebrate Community Survey Data for the Lower Passaic River Study Area | January 31, 2012 | Windward ([in prep]-m) |
| Late Spring/Early Summer 2010 Fish Tissue Collection Addendum to the Quality Assurance Project Plan: Fish and Decapod Crustacean Tissue Collection for Chemical Analysis and Fish Community Survey. Addendum 4 | June 21, 2010 | Windward (2010f) | 2010 Small Forage Fish Tissue Chemistry Data for the Lower Passaic River Study Area | July 18, 2012 | Windward ([in prep]-d) |
| Avian Community Survey Addendum to the Quality Assurance Project Plan: Fish and Decapod Crustacean Tissue Collection for Chemical Analysis and Fish Community Survey. Addendum No. 2 | August 9, 2010 | Windward (2010a) | Avian Community Survey Data Report for the Lower Passaic River Study Area Summer and Fall 2010 | August 8, 2011 | Windward (2011a) |
| | | | Avian Community Survey Data Report for the Lower Passaic River Study Area Winter and Spring 2011 | July 17, 2012 | Windward ([in prep]-i) |
| Collection of Surface Sediment Samples Co-Located with Small Forage Fish Tissue Samples Addendum to the Quality Assurance Project Plan: Surface Sediment Chemical Analyses and Benthic Invertebrate Toxicity and Bioaccumulation Testing. Addendum No. 1 | August 13, 2010 | Windward (2010b) | 2009 and 2010 Sediment Chemistry Data for the Lower Passaic River Study Area | September 2, 2011 | Windward ([in prep]-a) |
| Habitat Identification Survey Addendum to the Quality Assurance Project Plan: Surface Sediment Chemical Analyses and Benthic Invertebrate Toxicity and Bioaccumulation Testing. Addendum No. 3 | September 13, 2010 | Windward (2010d) | Habitat Identification Survey Data Report for the Lower Passaic River Study Area Fall 2010 Field Effort | January 6, 2014 | (Windward 2014b) |
| Caged Bivalve Study Addendum to the Quality Assurance Project Plan: Surface Sediment Chemical Analyses and Benthic Invertebrate Toxicity and Bioaccumulation Testing. Addendum No. 4 | March 2, 2011 | Windward (2011b) | 2011 Caged Bivalve Study Data for the Lower Passaic river Study Area | July 18, 2012 | Windward ([in prep]-e) |
| Quality Assurance Project Plan, Lower Passaic River Restoration Project, Low Resolution Coring Supplemental Sampling Program, Rev. 3 | June 2012 | AECOM (2012a) | Low Resolution Coring Supplemental Sampling Program Characterization Summary | December 30, 2013 | AECOM (2013b) |
| Quality Assurance Project Plan, Lower Passaic River Restoration Project, Quality Assurance Project Plan/Field Sampling Plan Addendum, RI Water Column Monitoring/Small Volume Chemical Data Collection, Rev. 3 | July 2012 | AECOM (2011a) | Small Volume Chemical Water Column Monitoring Sampling Program Characterization Report | n/a | AECOM ([in-prep]-a) |
| Summer and Fall 2012 Dissolved Oxygen Monitoring Program Addendum to the Quality assurance Project Plan: RI Water Column Monitoring/Physical Data Collection for the Lower Passaic River, Newark Bay, and Wet Weather Monitoring | August 6, 2012 | Windward (2012c) | Dissolved Oxygen Monitoring Program Data Report for the Lower Passaic River Study Area: Summer and Fall 2012 | September 3, 2013 | Windward ([in prep]-k) |

Table 2-3. RI QAPPs and Data Characterization Reports

| QAPP | | | Data Report | | |
|---|---|---|---|---|---|
| Document Title | Submittal Date | Reference | Document Title | Original Submittal Date | Reference [a] |
| Quality Assurance Project Plan, Lower Passaic River Restoration Project, Low Resolution Coring Supplemental Sampling Program Addendum, Second Supplemental Sampling Program, Rev. 1 | September 21, 2013 | AECOM (2013a) | SSP2 Data Report | n/a | AECOM ([in-prep]-c) |
| Background Tissue Addendum to the Quality Assurance Project Plan: Fish and Decapod Crustacean Tissue Collection for Chemical Analysis and Fish Community Survey. Addendum No. 5 | October 10, 2012 | Windward (2012b) | 2012 Fish Tissue Survey and Chemistry Background Data for the Lower Passaic River Study Area | n/a | n/a |
| Background and Reference Conditions Addendum to the Quality Assurance Project Plan: Surface Sediment Chemical Analyses and Benthic Invertebrate Toxicity and Bioaccumulation Testing. Addendum No. 5 | October 26, 2012 | Windward (2012a) | 2012 Benthic Invertebrate Community Reference Data for the Lower Passaic River Study Area | August 26, 2013 | Windward ([in prep]-f) |
| | | | 2012 Sediment Toxicity Reference Data for the Lower Passaic River Study Area | October 22, 2013 | Windward ([in prep]-h) |
| | | | 2012 Sediment Chemistry Background Data for the Lower Passaic River Study Area | October 30, 2013 | Windward ([in prep]-g) |
| Quality Assurance Project Plan, Lower Passaic River Restoration Project, RI Water Column Monitoring/High Volume Chemical Data Collection, Rev. 2 | December 2012 | AECOM (2012b) | High Volume Chemical Water Column Monitoring Sampling Program Characterization Report | n/a | AECOM ([in-prep]-b) |
| Carp Harvest Pilot Study Addendum to the Quality Assurance Project Plan: Fish and Decapod Crustacean Tissue Collection for Chemical Analysis and Fish Community Survey. Addendum No. 6 | September 11, 2013 | Windward ([in prep]-j) | n/a | n/a | n/a |

Notes:
FS = feasibility study
PWCM = physical water column monitoring
QAPP = quality assurance project plan
RI = remedial investigation
SSP = supplemental sampling program

[a] Documents previously submitted and currently in preparation are in revision in response to EPA comments.



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